

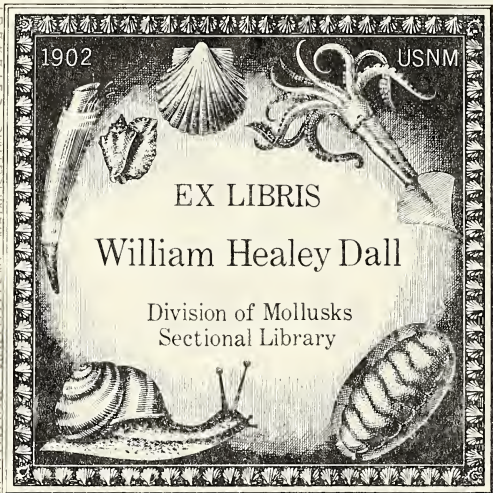
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BULLETIN for 1971



AMU, Thirty-Seventh Annual Meeting

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1971-1972

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THE AMERICAN MALACOLOGICAL UNION, Inc.



BULLETIN
for 1971



AMU, Thirty-Seventh Annual Meeting

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THE AMERICAN MALACOLOGICAL UNION, Inc. THIRTY-SEVENTH ANNUAL MEETING

Cocoa Beach, Florida

July 15-19, 1971

The festivities began even before the official opening of the 37th Annual Meeting. Those who arrived at the Atlantis Motel in Cocoa Beach on July 14th found at the registration desk a large sign inviting everyone to cocktails and supper at the home of Mrs. Smith Whiteside in Indian Harbour Beach. There were cocktails at poolside, and a buffet supper offering an assortment of casseroles and salads prepared by members of the Astronaut Trail Shell Club. The mood was festive, and AMU members filled the patio, living room and dining room of Jeanne's new home. (Pronounce her name "Johnnie".) The only regrets to be heard concerned an inability to sample all the many delicious casseroles.

This party seemed to set the tone for the whole meeting, which was notable for its more leisurely than usual pace, providing a greater opportunity for asking questions of speakers, and for personal contact and conversations with other members. The heat and humidity, and the rain which came almost every afternoon, did nothing to dampen the members' spirits.

The morning of July 15th was registration time at the Atlantis Convention Center, a time for greeting old friends and acquaintances not seen for a year or more. Many familiar faces were missing, mostly because of collecting trips to distant parts of the world or other activities. Although 125 were registered, there was no lack of enthusiasm. The souvenirs distributed at registration included a large live-collected *Murex fulvescens* for each person. Some members had already collected shells on the beach and among the green plants outside the Convention Center.

The Annual Meeting was called to order at 1:30 p.m. with a welcome by Mrs. Eleanor Hillman, local committee co-chairman, and from Tom Sproul, City Manager of Cocoa Beach. President Stansbery responded on behalf of the AMU and introduced the first of the 30 papers.

The informal gathering Thursday night was highlighted by Dr. Larry Mertens, an underwater photographer and instructor in that specialized art.

Friday night was Shell Club Night. Highlight-

ing the evening were many slides of shells and living mollusks, brought by shell club members. More and more people are tackling the demanding task of photographing live mollusks, with excellent results. The Question Box was opened and Dr. Clench answered a number of questions for members. Door prizes were six specimen shells, donated by members. Because of the late hour, we were not able to have the club reports read aloud, but they will be printed in more detail in the Spring 1972 Newsletter.

Sunday was a purely social day, highlighted by a picnic on North Grange Island, in the Indian River near Grant, Florida. We were taken up the coast by bus and had our daily rain shower while waiting for the barge and boat that took us to the island in shifts. The delicious meal of clams, chicken, corn on the cob, potatoes and carrots was more than most of us could finish. The picnic was catered by a local group, and proceeds were added to a scholarship fund for local children. Some of us had brought collecting gear. Many shells were to be found around the small, sandy island, but the live ones were mostly small, common species. We were surprised to find that most of the plentiful clam shells were *Mercenaria mercenaria*, not *M. campechiensis*, and we were told that they were harvested commercially. At least one member came back with a live angel wing, which was on display in a bucket of water the next day.

Sunday night was another evening of films, scheduled at the same time as the Executive Council meeting, so not all members were able to attend. Monday was the last day for papers, with a workshop on rare and endangered mollusks in the afternoon, at which Mr. Earl B. Baysinger of the Office of Endangered Species of the Department of Interior spoke. This was followed by the annual Business Meeting.

While the meeting room was being transformed into a banquet hall, the members changed into their finery. As we entered the hall, the most striking feature was the decorations — centerpieces with foot-long horse conchs and lightning whelks, surrounded by other local shells plus preserved echinoderms. After the buffet-style

dinner, Karl Jacobson spoke on the history of Cuban Malacology in his own inimitable way. President Stansbery introduced the other officers and the Past Presidents in attendance. Mrs. Hillman supervised the distribution of an extraordinary number of doorprizes. The first prize, won by Carl Gugler, was the main decoration on the dais, a beautiful arrangement of shells and other marine life on a foam plastic base. The artist had thoughtfully used a minimum of water-soluble glue in putting it together, so that the recipient could take it apart easily. Each member found one or more shells at his place when he sat down, from the Central Florida Shell Club as well as the host club. All were delighted to hear that they could also take the shells used as decorations. There were still more shells in boxes at the rear of the room, and many members went through them and left with bags full of "goodies". The committee was even thoughtful enough to provide paper bags for those taking shells. All the shells had come from commercial fisherman (probably scallop dredgers) working 30 miles east of Cape Canaveral.

The last day saw the remaining members going off on field trips, both marine and fresh water. The shore collecting trip was scheduled to take advantage of the lowest tides. A number of smaller species were found alive, especially at Sebastian Inlet. Your secretary went on the fresh water collecting trip to a creek tributary to Lake Washington. This spot provided several species of mussels in quantity, plus *Helisoma* and *Pomatia* snails. Even the professionals said they had never had any easier collecting. Although it was not difficult to feel the mussels in the mud among the roots of the water lilies, it was even easier to walk along the banks of the creek and find scores of mussels that had been "collected" and eaten by some animal. Dozens of the mussels were still in

pairs, and some of the well-cleaned but unbroken apple snails even had operculums nearby. With Dr. Morrison, some of us went on to a collecting spot on the St. James River nearby, where we found mostly the same species plus one *Elliptio* not previously recorded from that area.

Looking back over the week, we realized that conservation was the topic that kept recurring, in private conversations as well as formal meetings. Fresh water mollusks are the ones most endangered, both from pollution and from the builders of dams. The dams create deep lakes, and many populations of mollusks cannot live in deep water. Although marine mollusks are not in such immediate danger, we should all be aware that overcollecting live mollusks could endanger populations. Conservation should always be in mind.

The most important thing at a convention is the papers presented, but perhaps the part an individual remembers most about a particular convention is the people with whom he came in contact. We have especially fond memories of the Astronaut Trail Shell Club members who worked long and hard to make our stay in Cocoa Beach most pleasant. They had extraordinary problems to overcome. The principal problem was the motel, which had changed ownership. Bess Severance, Eleanor Hillman, and others from the Club were always at the registration desk, ready to help members with their large and small problems. There were many especially thoughtful touches, like the coffee urn and hot water for tea in the meeting room. The amount of shells they had collected live and cleaned for us was overwhelming. Very few of these people had been to an AMU Meeting before. We hope that many of them will be at Galveston next year to renew acquaintances and to really enjoy a convention.

Marian S. Hubbard
Recording Secretary

NOTES ON MALACOLOGY IN CUBA

Morris K. Jacobson

AMERICAN MUSEUM OF NATURAL HISTORY
NEW YORK, NEW YORK
SUMMARY OF BANQUET ADDRESS

Cuba, like the other Greater Antilles, is uniquely rich in land shells, specially land prosobranchs of the families Pomatiidae and Helicinidae. It is very rich but not necessarily richer than Jamaica and Hispaniola and probably, like the other two richer than Puerto Rico. Yet in malacology Cuba is — or until recently was — far ahead of the others. The mollusks have been more thoroughly studied in Cuba, by foreign and native specialists, and have been more enthusiastically collected by foreign and Cuban amateurs than those of any country in the New World besides the United States. Thus, regions like Mexico and Hispaniola, which are blessed with the richest of land snail faunas, have never aroused enough popular interest to form a conchological society or to publish a malacological periodical. And it was only in very recent years that some display of interest in shells began to develop in Brazil and Uruguay. But in the rest of the Americas with the exception of Canada there is not a sign.

In Cuba also, though many European and Cuban specialists studied the native mollusks, there was at first little popular interest in the subject. It was not until the 1940's that a big boom in popular interest took place as a result of which the first malacological society outside the United States and the first malacological periodical besides those in the United States was established. Large numbers of Cubans became enthusiastic shell hobbyists and large and valuable private collections were formed. What caused this boom, what happened to the collections made, and what the present day status of the subject is in Castro's Cuba — as far as I could determine — will be the subject of my talk.

The highwater mark of this interest in malacology lasted from about 1942, when the *Sociedad Malacológica 'Carlos de la Torre'* was formed in Havana, to approximately 1954, when the *Revista de la Sociedad Malacológica 'Carlos de la Torre'* was suspended after having gone through two numbers of volume 9. The boom finally came to an end when the Sociedad, together with all

private associations, were abolished in the early 1960's by the Communist government. Together with this abolition of the Sociedad came the more or less voluntary donation of all private collections to the new Academia de Ciencias where indications are that they are being somewhat less than satisfactorily cared for.

The first Cuban land shells which came to the attention of Europeans were not recognized as such. Thus *Helix picta* Born (now *Polymita*) was thought to have come from the coast of Italy and *Buccinum fasciatum* Müller (now *Liguus fasciatus*) was reported from the Indies. Even as late as 1838, Isaac Lea described *Helicina pulcherrima* (now *Emoda*) as coming from Java. The first shell named which was known to come from Cuba seems to be *Helix bonplandi* Lamarck 1820 (now *Eurycampta*).

In the early and middle 19th century several European travellers came to Cuba where they collected many species and later described them in German, English, French, and Spanish publications. Among these men should be mentioned Arthur Morelet, Ludwig Georg Karl Pfeiffer, who in 1839 wrote the first specialized paper on Cuban land shells, Alcides Dessalines d'Orbigny, whose malacological contribution to the huge *Historia Física, Política, y Natural de la Isla de Cuba* by Sagra (1842-1845) is one of the most important works on the subject. Mention must also be made of Johannes Christoph Gundlach, the gentle German scholar who came to Cuba in 1838, fell in love with it and stayed there till his death in 1896. One of the best foreign collectors was the American, Charles Wright, who wandered about on foot in the Cuban countryside, collecting plants and shells for specialists to describe and name.

Among the Cubans of this period we must not omit Felipe Poey y Aloy, the greatest of Cuban naturalists as well as one of the leading geniuses which the New World produced. He deserves to be far better known to us than he is. The only Cuban of the period who largely specialized in mollusks was Rafael Arango y Molino whose catalogue of

Cuban shells (*Contribución a la Fauna Malacológica Cubana* (1878-80) remains even today the best single work on the subject ever published.

The later Cuban and American students of Cuban mollusks are too numerous to mention. They would include practically every American malacologist of note, such as Pilsbry, Bartsch, Henderson, Clench, etc. etc. Among younger Cubans we must at least mention the names of Carlos Guillermo Aguayo, Miguel L. Jaume, and Luis Howell Rivero. But there are many many more. The dean of Cuban malacologists was Don Carlos de la Torre y Huerta who died in 1956. His career as politician, educator, naturalist, and malacologist deserves an essay in itself.

But until the 1940's the study of snails remained largely the exclusive province of specialists and trained observers. Then an event occurred which made the 'caracolitos' one of the most popular hobbies among the Cubans of leisure.

This was the publication in 1938 by the United States National Museum of THE CUBAN OPERCULATE LAND SHELLS OF THE SUBFAMILY CHONDROPOMINAE by Carlos de la Torre and Paul Bartsch, to be followed in 1941 by the same authors' THE CUBAN OPERCULATE LAND MOLLUSKS OF THE FAMILY ANNULARIIDAE, EXCLUSIVE OF THE SUBFAMILY CHONDROPOMINAE, and in 1942 by THE CYCLOPHORID OPERCULATE LAND MOLLUSKS OF AMERICA, in which they were aided by Joseph P. E. Morrison.

These handbooks had certain great advantages: they were superbly illustrated and printed, they provided clear and detailed locality data for each taxon described — a point of tremendous value in Cuba where many species have a fantastically restricted range —, and they were easily accessible and cost less than \$2 each. I found all three works in the hands of all the Cuban shell people I ever visited. The appearance of these three works drove many Cubans into a collecting frenzy. Other hobbies were given up for the 'caracolitos.' Even popular weeklies of large circulation, such as BOHEMIA, had to take notice of the craze. Making land shell collections and naming "novedades" (new species) blossomed as readily as the excellent Cuba tobacco and sugar cane under the hot subtropical sun.

As a result, every nook and cranny was hunted down for snails. Cuba became splendidly known conchologically. A side result was that the first inklings of the need for conservation of the incomparable snail fauna began to appear.

But the three monographs which caused this *furor malacologicus* were not without their faults. The descriptions were lengthy and repetitive and it was difficult to winnow the diagnostic features from the chaff of repeated adjectives. However, this fault was largely overcome by the truly excellent illustrations and admirable locality data. Probably most readers relied on the figures and the precise locality data alone to name up their hauls.

A somewhat more serious fault was the over-naming of taxa on the basis of variable details of shell morphology. Unfortunately this became a tradition which was followed by the authors of the REVISTA, and as a result the Cuban land fauna is overburdened with many useless names. Of course, it is not the only one.

I can only say a few words about the status of malacology in modern day Cuba. From the little I could learn, there still seems to be a good deal of study going on in very restricted circles. Unfortunately, pitifully little of this is being published. Moreover the few students still trying to do work in the field find themselves seriously hindered by an almost complete lack of the rich modern literature which is the blessing of the science today.

To conclude, I see the tasks of a revived interest in Cuban malacology to consist of the following:

- 1) the continued collection and description of the fauna, since the restricted habitat of many species and the increased industrialization of the country will put the existence of many molluscan forms into jeopardy;
- 2) intensive studies of the life history — including ecological requirements — of even the better known groups;
- 3) the care and maintenance of the important type collections present in various Cuban museums;
- 4) and the thorough revisions of the fauna in the light of newer taxonomical concepts.

STRUCTURAL AND DECORATIVE USE OF SHELL IMAGES IN AMERICAN FURNITURE BEFORE 1850

Glenn A. Long
TOWSON, MARYLAND

SUMMARY

This is the first paper in a series meant to describe the origins of shell decorations on early American furniture. It deals with the appearance of these shell images, their similarity to other decorative elements, and their structural relation to living zoological specimens.

During the initial stages of research, this writer has assumed that the selection of certain kinds of shell images by American furniture makers signifies some kind of specialized cultural function or meaning. Fascination with and classification of things in nature, popular within intellectual circles in England during the late seventeenth, eighteenth, and early nineteenth centuries, provided a cultural context well suited to the practice of decorating elegant furnishings with shell carvings and inlays.

Three style periods are represented in early American shell ornamented furniture. They are (1) Queen Anne style (ca. 1720-1750); (2) Chippendale style (ca. 1750-1785); and (3) Classical style (ca. 1785-1840). Furniture from these periods are decorated with shells on the knees of the cabriole legs, on the aprons of case pieces and chairs, on the undulating front surfaces of block-front chests and desks, on the large central drawers of high and low chests, and on the tops of Classical style card tables, dressing tables, and desks.

Carved shells of a type resembling the family *Pectinidae* are commonly found on furniture made in eastern Pennsylvania and Maryland. There are regional variations of these carvings which occur within this area of the eastern seaboard and are significant in making stylistic attributions of works to known craftsmen. In New England are found examples made in and around Newport, Rhode Island which seem to have been inspired by *Tridacna gigas* and its related species. There is an ancient Greek ornament called the anthemion which seems to have been combined with shell carvings and contributed to the imaginative freedom seen in carvings made by Chippendale

cabinetmakers. Inlaid shell ornaments occurring in the late eighteenth and early nineteenth centuries seem to be illusionistic versions of exotic gastropods. Some of these inlays might well have been inspired by such marine shells as *Strombus gallus* Linne and *Lambis violacea* Swainson. Thomas Seymour, a cabinetmaker from Boston, is known to have commissioned a local artist to decorate a Classical style commode with a painting of six gastropods.

Three questions conclude this survey of early American shell ornamentation. One of them is this: Is it possible to make a definitive attribution of a piece of Queen Anne, Chippendale or Classical style furniture to a given cabinetmaker through study and comparison of shell carvings and shell inlay selections? This might well become the thesis question for a second paper in this series.



PLATE 1

DESSING TABLE — Chippendale style
ca. 1760
Walnut

Detail of shell carving on cabriole leg.

Reproduced through the courtesy of
Mrs. William D. Poultney.

KUDZU VINE AND AN ASSOCIATED LAND SNAIL FAUNA

Dorothy E. Beetle

PENINSULA NATURE MUSEUM
NEWPORT NEWS, VIRGINIA

An accidental fire set by a passing train burned over the north boundary of the woods surrounding the Peninsula Nature Museum, Newport News, Virginia, on March 28, 1971. This area had been completely taken over by Kudzu vine which had spread from the slopes of an adjacent railroad overpass. The fire burned off all of the leaf litter, exposing bare sand. Snail shells were lying in considerable numbers on the surface of the sand. All that was required was to lay out square yard plots, count the shells and collect them for identification.

Ten species of land mollusks were found on the steep slopes of the railroad overpass. Three additional polygyrids were on the floor of the woods.

Newport News lies on a peninsula which juts into Chesapeake Bay. The climate is mild with abundant rain. Originally the land where the museum and overpass are situated was covered with a mixed pine and hardwood forest. White and black oaks and hickories are abundant. Sweetgum, red maple, beech, tulip tree, and the shrubby dogwood, sourwood and alder occur in the area. The soil is coarse sand, with crossbedded sands, gravels and clays extending downward to considerable depths. At the museum the elevation is only 45 feet above sea level.

When the highway and overpass were constructed in 1958, the steep sandy slopes were planted with Kudzu vine to prevent erosion. There is no denying that Kudzu prevents erosion, but it rapidly forms a dense mass that smothers local vegetation. Volunteer plants are unable to establish themselves and the Kudzu invades roadside and forest, far beyond its original planting.

Currently the Kudzu vine has invaded the woods belonging to the Nature Museum, and will eventually destroy our nature trails unless funds can be found to spray and kill the vine and replant native vegetation. Shrubs have been smothered under festoons of vine and the tallest trees have been killed as their crowns were covered. Under the trees only scattered patches of moss, grass and a few early spring flowers, that bloom before the Kudzu becomes active, have survived.

In fall the vine becomes dormant and sheds its leaves. On the ground there is a brittle mat of dead leaves resting slightly above the soil on the vines which thickly crisscross everywhere. These leaf mats can be lifted intact to expose the bare sand beneath them.

Even in the woods the sand permits rapid leaching of material and only a thin humus layer is formed. Under the Kudzu vine desiccated plant material consists almost entirely of the previous year's growth. On the steep slopes of the overpass the sand has almost no trace of plant debris in unburned areas.

In spite of the exposed habitat of the dry steep overpass slopes, the most species were found here, although the largest population of polygyrids was concentrated at the base of the slope and on the level ground under the dead trees. Following is a list of the species occurring at several stations and the number of shells found.

Station 1. One square yard, 35° slope almost under the overpass, 3 feet above ground level.

Triodopsis juxtidentis 9
Retinella indentata paucilirata 1
Hawaiiia minuscula 3
Ventridens cerinoideus 1
Zonitoides arboreus 2
Helicodiscus parallelus 1
Strobilops labyrinthica 5
Gastrocopta contracta 17
Vertigo oscariana 1

Triodopsis juxtidentis and *Gastrocopta contracta* were most numerous at this station. While *Triodopsis* was numerous all through the one and one half acre tract, *Gastrocopta* was only abundant here. Only one shell of the minute *Vertigo oscariana* was found, although the slopes and floor of the woods were searched for more shells. Below this station, at the base of the slope, 9 *Triodopsis albolabris* were lying.

Station 2. One square yard on low slope of embankment, 15 feet from entrance to museum grounds.

Triodopsis juxtidentis 8
Retinella indentata paucilirata 3
Helicodiscus parallelus 2
Succinea sp., juvenile 2
Gastrocopta contracta 1

Station 3. Floor of forest, under and around fallen log 4 inches diameter. Standing trees dead, area bare of native plants.

Triodopsis juxtidentis 28
Triodopsis fallax obsoleta 4
Helicodiscus parallelus (under log) 6
Retinella indentata paucilirata (under log) 2

Transect, 50 feet long, 1/2 foot on either side of line, forest floor invaded by Kudzu Vine.
Triodopsis juxtidentis 19

T. fallax obsoleta 6
T. albolabris 12
Mesodon thyroideus 5
Retinella indentata paucilirata 1
Ventridens cerinoideus 1
Hawaiia minuscula (under log) 1

In woods still free of Kudzu vine, a search under old logs and through the leaf litter turned up the same animals except for *Succinea* sp., *Gastrocopta contracta* and *Vertigo oscariana*. *Triodopsis juxtidentis* and *Helicodiscus parallelus* were most abundant. This area is somewhat disturbed due to the fairly heavy recreational use.

Gratitude is expressed for the assistance of F. Wayne Grimm for identification of several snails.

LAND SNAILS OF THE CHISOS MOUNTAINS, BIG BEND NATIONAL PARK, TEXAS

Wm. Lloyd Pratt

COLLECTIONS DEPARTMENT,
FORT WORTH MUSEUM OF
SCIENCE & HISTORY
FORT WORTH, TEXAS

The Chisos Mountains are a rhyolitic igneous range rising to an elevation of 2568 m out of the Chihuahuan desert of southern Brewster County, Texas. A single uplifted remnant of upper cretaceous limestone is included in the range. The range is surrounded by shrub desert and is isolated from the Sierra Fronteriza of northwestern Coahuila, the nearest wooded range, by a distance of about 80 km. It is doubtful that a continuous habitat suitable for montane land snails has existed between the ranges during pleistocene or recent times (Wells, 1966). The upper bajada slopes and foothills support poorly developed succulent desert (Gehlbach, 1967). Above about 1500 m the range is vegetated by evergreen woodland, with limited areas of deciduous woodland in protected canyons. Two dominance types of Pinyon-Oak-Juniper woodland correspond to the *Quercus-Juniperus* types a and b of Gehlbach (1967). The xeric type, occupying the majority of the wooded sites in the range, is dominated by *Pinus cembroides* (Mexican Pinyon), *Quercus grisea* (Gray Oak), *Juniperus flaccida* (Drooping juniper), and *J. pinchotti* (Red-berry Juniper), of relatively low stature, more open spacing, and less mesic shrub and herb layers. The mesic type, occupying the floor and lower slopes of protected canyons, at elevations above 1800 m is dominated by *P. cembroides*, *Q. grisea*, and *J. deppeana* (Alligator-bark Juniper), with *Cupressus arizonica* (Arizona Cypress) and *P. ponderosa* (Ponderosa Pine) locally attaining co-dominant status and with *Pseudotsuga menziesii* (Douglas Fir) as a local constituent. The stature is taller, the spacing is closer, and the inferior layers more mesic and more diverse than in the xeric type. Whitson (1965) describes the mesic dominance type of Boot Canyon. Deciduous woodland is restricted to the most mesic conditions, such as the stream-bed and adjacent floor of canyons, the vicinity of springs, and protected north-facing slopes. The

deciduous woodland is dominated by *Q. gravesi* (Graves Oak) with *Acer grandidentatum* (Big-tooth Maple) as a local co-dominant.

The purely igneous foothills and bajada of the Chisos Mountains do not support a land snail fauna. Elsewhere in the region, on limestone and calcareous alluvium, there is a distinctive desert fauna, completely separate from the montane fauna herein described. Studies of these desert calciphiles have barely started and are not reported at this time. Snail habitat in the xeric evergreen woodland is limited. Snails are largely restricted to the leaf mold beneath dead, decaying *Agave harvardiana* (Harvard Agave) and to rocky ledges. Population levels are low, and most areas are devoid of snails. *Gastrocopta ashmuni* (Sterki), *Polygyra chisosensis* Pilsbry, and *Humboldtiana agavophila* Pratt comprise the fauna. In the mesic evergreen, woodland snails are found under rocks, logs, and dead *Agave*. Populations are generally sparse, but snails may be locally abundant under good cover. *Cionella lubrica* (Muller), *Pupilla hebes* (Ancey), *Gastrocopta pellucida* (Pfeiffer), *G. pentodon* (Say), *Helicodiscus singleyanus* (Pilsbry), *Radiodiscus millicostatus* Pilsbry and Ferriss, *Glyphyalinia indentata* (Say), *Eucolulus fulvus* (Muller), *P. chisosensis*, and *H. agavophila* make up the fauna. In the deciduous woodland, snails are found under rocks and logs, in talus slopes, and in the leaf litter. *G. pentodon*, *Columella alticola* (Ingersoll), *Pallifera* sp., *Helicodiscus eigenmanni* (Pilsbry), *H. singleyanus*, *Punctum vitreum* (H. B. Baker), *R. millicostatus*, *G. indentata*, *E. fulvus*, *Striatura meridionalis* (Pilsbry and Ferriss), *Pseudosubulina cheatumi* Pilsbry, *Thysanophora horni* (Gabb), *Microphysula ingersolli* (Bland), and an undescribed *Humboldtiana* living in shaded talus (Boot Canyon) comprise the fauna. The cool, moist interiors of rock slides and of crevices in sheltered cliffs comprise a distinctive habitat. *Cionella lubrica*, *P.*

hebes, *G. pentodon*, *H. singleyanus*, *R. millecostatus*, *G. indentata*, *E. fulvus*, *P. cheatumi*, *P. chisosensis*, *Humboldtiana chisosensis* Pilsbry, probably *H. edithae* Parodiz, and four undescribed *Humboldtiana* have been collected to date. Pilsbry collected a *Pallifera* sp. in this habitat (Metcalfe, 1970). The rockslide habitat transgresses the three above mentioned habitats, and its fauna is a mixture of species characteristic of the deciduous woodland and mesic evergreen woodland with specialized forms not found outside of rockslides. The uplifted remnant block of limestone which forms Laguna Meadow and the eastern side of Ward Mountain (Elevation ca. 2200 m.) supports an interesting calciphilous fauna. Although the habitat is xeric evergreen woodland, the fauna found under dead *Agave* and in the leaf litter under thickets of *Q. intricata* (Chihuahua Scrub Oak) resembles that of the mesic evergreen woodland more closely and includes two apparently obligate calcicoles, *Vallonia perspectiva* Sterki and a *Succinea* species. The fauna also includes: *P. hebes*, *G. pellucida*, *G. ashmuni*, *H. singleyanus*, *G. indentata*, *E. fulvus*, and *H. agavophila* (type locality). Population density is higher than in any other habitat.

The zoogeographic affinities, with one possible exception, seem to be with the Southwestern and Mexican Plateau provinces of the Western American division. *Gastrocopta pellucida*, *G. pentodon*, *Helicodiscus singleyanus*, *Glyphyalinia indentata*, and *Striatura meridionalis* are widespread species; *Helicodiscus eigenmanni* and *Thysanophora horni* occur in both the Texan and Southwestern provinces and *T. horni* in the Mexican Plateau as well.

Pseudosubulina cheatumi, *Polygyra chisosensis*, and the genus *Humboldtiana* are Mexican, and the remaining species are Southwestern, with one exception. *Punctum vitreum* is Texan, but it is known from the state of Vera Cruz and may occur in the ranges of the Mexican Plateau. The almost total lack of information on land snails in the mountain ranges of the Chihuahuan desert region (=Mexican Plateau) is a stumbling block to zoogeographic speculations. The data would seem to show that the fauna is transitional between the Sonoran desert region (=Southwestern) and the Chihuahuan, but it is conceivable that virtually all of the "Sonoran" forms in the Chisos fauna occur also in the Chihuahuan and that the fauna is entirely Chihuahuan in origin. The latter case seems more likely in view of the situation in regard to plants and other animal groups.

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DELAYED OVIPOSITION IN *HELICODISCUS*

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SUMMARY

In the endodontid pulmonate, *Helicodiscus parallelus* (Say) eggs are assembled singly in the mid-region of the spermovi duct. The initially transparent egg shell accumulates calcareous granules and becomes opaque, but still remains flexible, during the first 4 to 6 days. The egg is retained in the spermovi duct until the embryo has reached a relatively advanced stage. The egg then is deposited in the substratum or in a crevice in decaying wood, where the developmental sequence is completed.

Adults measure 3.0-3.8 mm in diameter. The developing egg in the spermovi duct is sausage-shaped and measures about 2.5 mm in length and about 0.7 mm in diameter. A newly deposited egg assumes a sharply ovoid outline and measures on the average 2.1 mm in length and 1.5 mm in greatest diameter. Developmental time in the spermovi duct is 36 to 40 days under laboratory conditions. An additional 6 to 8 days elapses between deposition and hatching. Newly hatched snails measure 1.5 to 1.7 mm in diameter.

MICROANATOMICAL STUDIES OF *DENTALIUM PILSBRYI*

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The anatomy of *Dentalium pilsbryi* Rehder, 1942 was investigated. There is a single kidney, located anterior to the digestive gland in a blood space which offers a free communication between excretory, digestive, and reproductive systems. A duct from the kidney passes anteriorad through the muscle septum and joins the gut near the radular cavity. Anterior to the kidney is a structure which could be called a heart. It is vesicular, is incompletely bounded by an epithelium, and consists of a spongy mass of cells. Neither a pericardial cavity nor a renopericardial system, in the usual sense, exists.

The single gonad duct opens broadly into the blood space around the kidney. A duct from the blood space leads to a papilla on the mid-dorsal wall of the mantle cavity. It is through this duct that the gametes may be discharged to the ex-

terior by way of the mantle cavity.

The digestive system has a single opening, the mouth. The esophagus originates at the right side of the radular cavity. After a number of complex convolutions the digestive tube passes through the muscle septum and receives the ducts of the digestive glands in an inflated region which could be called the stomach. The intestine leaves the stomach region, goes through the muscle septum and forms a diverticulum which is filled with excretory spherules. The intestine then joins the radular sac by way of a broad, transverse, slit-like opening in the dorsal wall of the radular sac.

A cartilaginous ring, made up of segments, is located near the anterior edge of the mantle. A probable function of this ring is to provide support for the mantle opening, permitting efficient operation of captacula and foot.

CHITTY CHITTY BANG BANG

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In the middle of the last century the itinerant professor of Amherst College, Charles Baker Adams, described several species of minute land prosobranchs from Jamaica and established a new genus, *Stoastoma*, to separate them from their relatives in the New World Helicinidae. In addition to the small size, usually 1 to 3 mm in diameter with the exception of the type-species which reaches 5 or 6 mm, the taxon is characterized by distinctively developed sculpture, a feature so infrequently encountered in helicinids that when it does occur, authors normally recognize separate subgeneric or generic taxa. Finally there are radular peculiarities which have been noted by H. B. Baker.

Following quickly upon the death of Adams, who did not live long enough to illustrate his new species, Edward Chitty, an amateur enthusiast, Adams's man in Jamaica, English lawyer and judge, effectively stopped all interest in *Stoastoma* by publishing a monograph in the Proceedings of the Zoological Society of London in which sixty-one new species, two new varieties, and seven new genera were described and Adams's taxon elevated to the status of a family, the Stoastomidae. Only a line cut drawing of *S. pisum*, which has been reproduced subsequently several times, illustrated the group. The small size of the

specimens and the nomenclatorial overburden have prevented further work on *Stoastoma*, although several other species from other West Indian islands have been described. The title of this talk needs no explanation!

A study of the primary types of Adams's species, upon which Chitty based his 7 genera, allows recognition of the relative status of these taxa. Although the type-species were never delineated by Chitty, they were effectively designated subsequently by H. B. Baker and they are here illustrated for the first time. Most of the taxa are synonymous. *Stoastoma* itself, with the type-species, *S. pisum* may be presently separated from all of Chitty's genera by its larger size; its radula, according to Baker, forms a connecting link between the Vianinae (=Stoastomatinae) and the Helicininae. *Lindsleya*, tentatively placed as a subgenus of *Lucidella* by Baker, may be retained as a genus with *Metcalfeia*, with *Fadyenia* and *Lewisia* coming as possible synonyms. *Petitia* and *Blandia* are also synonymous, consisting of extremely tiny, depressed species, but *Wilkinsonaea* is very distinct conchologically, with heavy sculpture, a unique operculum and unusual digitiform processes forming an awning over the aperture (Plate 2, fig. 4).

ECOLOGICAL AND SYSTEMATIC NOTES ON CAECIDAE COLLECTED AT ST. CROIX, U.S. VIRGIN ISLANDS

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ABSTRACT

Seven species of Caecidae were collected by diving at St. Croix. Three species are known from

only four specimens, and little is known about the other species. Four live around coral reefs, but the other three have a wider range of habitats.

SYMPOSIUM ON MOLLUSCAN AQUACULTURE

WILLIAM N. SHAW, CONVENER

INTRODUCTION

In recent years there has developed a great interest in farming the sea. One reason is to fulfill the need for protein to feed the increasing world population. It is felt that this must be done by farming rather than hunting animals of the sea. When we compare the development of agriculture to aquaculture it is obvious that aquaculture is just in its infancy. A tremendous amount of time, money, and effort will be necessary before our technology in aquaculture approaches that which we already have in agriculture today.

This symposium reviews the present status of molluscan aquaculture in North America. Immediately it will be obvious that the oyster is one of the principal species presently being cultured and shows the greatest future potential. Our knowledge of this species is probably greater than any other marine mollusk. In addition, the oyster is a high priced commodity, an important prerequisite if molluscan aquaculture is going to be economically successful in North America.

Both the scallop and the hard clam show great potential in future molluscan culture.

Presently, molluscan aquaculture is highly successful in countries such as Japan and Spain. In Japan over 23 tons of oyster meats are being raised per acre per year while in Spain they are harvesting 120 tons of mussel meats per acre per year (Table 1). There is no reason why such yields cannot be realized in North America. At present the best yield for oysters in the United States is only 2.0 tons per acre per year, a far cry from those now being harvested in Japan.

Although molluscan aquaculture has attracted great interest in recent years there is still a considerable lack of know-how to make such ventures a commercial success. Many companies have blindly entered the field and have lost enormous amounts of money. It is knowledge being gained by people like those on the panel today, that will be necessary for a successful commercial program. You will learn after hearing these papers today that we have a long way to go.

TABLE 1. *Aquaculture yield of cultivated stocks or natural populations with no fertilization or feeding. Units in fresh weight, shells excluded.*¹

Country	Species	kg/ha/yr	t/acre/yr
U.S.	Oysters	9	0.004
	(National Avg.)		
U.S.	Oysters	5,000	2.00
	(Best Yield)		
France	Flat Oyster	400	0.16
	(National Avg.)		
France	Portugese Oyster	935	0.37
	(National Avg.)		
Australia	Oysters	150	0.06
	(National Avg.)		
Australia	Oysters	540	2.20
	(Best Yield)		
2/Japan	Oysters	58,000	23.30
(Inland Sea)			
Malaya	Cockles	12,500	5.00
France	Mussels	2,500	1.00
Philippines	Mussels	125,000	50.00
2/Spain	Mussels	300,000	120.00

¹. Source: The Status and Potential of Aquaculture. Volume I. Particularly Invertebrate and Algae Culture. John H. Ryther and John E. Bardach. 2. Calculations based on an area 25% covered by rafts.

THE ROLE OF GENETICS IN MOLLUSCAN MARICULTURE¹

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Compared to the successful results obtained through genetical selection, inbreeding and outbreeding of inbred lines, and by intraspecific and interspecific hybridization of terrestrial organisms, relatively little has been done with aquatic forms. Some notable exceptions are the bizarre forms of goldfish, the increased growth rates of pond-reared fresh-water trout and the success of obtaining faster growing and larger marine salmonoids. Genetical experimentation involving selection and breeding in bivalve mollusks had to await the development of reliable techniques (Reviewed by Loosanoff and Davis, 1963) for larval culture. This discussion is mainly concerned with research on oysters and quahog clams in the United States.

Longwell and Stiles (1970) discuss the genetic system of our native oyster (*Crassostrea virginica*) and suggest methods for enhancing their commercial qualities through breeding. They found that there was a high mortality of the second generation of inbred oysters, probably due to lethal genes. Imai and Sakai (1961) studied the Japanese oyster *C. gigas* from northern and southern areas, performing inbreeding experiments as well as cross breeding of oysters from the different areas. The F_2 generation between the forms showed no segregation but showed a higher adaptability to environmental conditions than did the inbred parental types, that would be of commercial importance. In the inbred lines they were able to obtain the F_3 's but found that the F_3 's had negative viability of the larvae although fertilization occurred.

Some of the commercial attributes that could be achieved from genetical research with oysters discussed by Longwell (1968), Longwell and Stiles (1970) and Menzel (1971) are: 1) resistance to disease, 2) better growth, 3) better adaptation to environmental conditions of temperature, turbidity and salinity, 4) growth at a uniform rate to eliminate culling, 5) increased reproductive capacity, 6) decreased reproductive capacity or even sterility associated with better growth. 7)

hybrid vigor of out-crossing of inbred lines, 8) incorporation of desirable traits through interspecific hybridization, 9) genetic mutation by irradiation or other means with inheritance of possible mutated desirable traits, and 10) possible polyploidy with associated gigantism.

Galtsoff and Smith (1932) cross fertilized the Japanese oyster, *C. gigas*, and the American oyster, *C. virginica*, and obtained development of the larvae. Techniques were not available at this time to rear these but later Davis (1950) and Imai *et al.* (1950) found that the hybrid larvae lived only a few days. Imai and Sakai (1961) reared the hybrid between their *C. gigas* with the Portuguese oyster *C. angulata*. Menzel (1968) reared several combinations of hybrids through to sexual maturity among the species *C. gigas*, *C. angulata*, *C. rhizophorae* (the mangrove oysters from the West Indies and Central America) and *C. virginica*, including hybrids between *C. gigas* and *C. virginica*.

Chromosomal analyses were made in all the F_1 hybrids of mitoses and meioses in some as well as mitoses in some larval F_2 hybrids. A move to a new laboratory site resulted in unsatisfactory water quality and all the F_1 hybrids died, after living more than a year, before complete analyses could be made. Chromosomal behavior in the hybrid of *C. angulata* and *C. gigas* was apparently normal as was the hybrid between *C. rhizophorae* and *C. virginica*. The other combinations of hybrids had considerable meiotic anomalies in the F_1 and mitotic anomalies in the F_2 hybrids. The hybrids had mostly intermediate shell characteristics and growth patterns of the parents. Not enough data were obtained to propose any commercial applications, except it was noted that those hybrids in which *C. gigas* was a parent had greater growth than the others.

Hard clams or quahogs are the second most valuable mollusks in the United States. The majority of the commercial fishery is for the northern quahog, *Mercenaria mercenaria*, and the southern quahog *M. campechiensis* is a relatively

unimportant fishery, one reason being that this species quickly gapes and dies when removed from the water, hence causing it to be unsuitable for the very valuable shell trade.

Experiments were conducted that demonstrated that the clams could be grown commercially in mariculture, if suitable precautions were taken to prevent mortality from predation (Menzel and Sims, 1962). Seed clams would have to be supplied from a hatchery, as the natural recruitment is too

erratic. The two species hybridize readily in the laboratory (Loosanoff, 1954) (Plate 2, figs. 1-3) and the F_2 hybrid has been grown (Menzel, 1970) as well as the F_3 's. Growth experiments in Franklin County, Florida (Menzel 1962) have shown that it is possible to produce commercial size northern quahogs for the shell trade in about two years and the southern in half the time. Concurrent growth experiments of the hybrid showed that their growth was equal to the faster growing southern parent. The hybrids had almost as good keeping qualities when removed from the water as the northern parent. These data along with the necessity to use hatchery produced seed, leads to the recommendation that hybrid clams be used in mariculture.

In summary it may be stated that we are on the threshold of employing genetic manipulations in improving the commercial yield of marine mollusks. We have some of the basic information and it has been demonstrated in some instances that improvements can be made. So far the commercial fishermen are working with wild animals even though oysters have been cultivated since ancient times. The increased interest in mariculture and the increase in shellfish hatcheries, coupled with large investments, would seem to make the approach imperative. What is needed is a concentrated effort by governmental agencies as well as private industry to apply some of the findings as well as to continue to intensify the basic and applied research, similar to what has been done with terrestrial commercial organisms.

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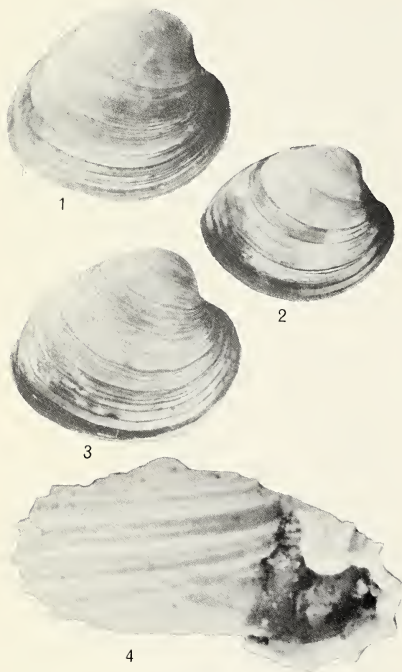


PLATE 2

FIG. 1 *Mercenaria campechiensis* (Apalachicola Bay, Florida area) 85 mm length.

FIG. 2 *M. mercenaria* (Great South Bay, New York) 74 mm length.

FIG. 3 F_1 Hybrid of *M. Campechiensis* X *M. mercenaria* 87 mm length.

FIG. 4 *Stoaostoma* (Wilkonsonaea) *gouldianum* C. B. Adams 3 mm diameter. (See article by K. J. Boss, p. 00)

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RECENT ADVANCES IN CLAM AQUACULTURE

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This paper will center primarily on recent aquacultural methods developed for the northern quahog, *Mercenaria mercenaria* (Linne), in our area of the western Atlantic. It is realized that similar work is also being done on other clams, for example, the soft-shell clam, *Mya arenaria* Linne in Dennis, Massachusetts by the Aquacultural Research Corporation.

Credit for much of the material included in this discussion is extended to Mr. Michael Castagna of the Virginia Institute of Marine Science Laboratory in Wachapreague, Virginia and to Mr. Elwood Bayer of the Coastal Zone Research Corporation Laboratory in Southport, North Carolina. Aquaculture studies at the University of North Carolina Institute of Marine Sciences were aided by NOAA Office of Sea Grant, Department of Commerce, under Grant #GH-103 U.N.C.

At present there are more than 15 laboratories or companies on the East Coast engaged in development of clam hatchery techniques. Most are in the Chesapeake and New England regions. Probably less than a third have reached commercial capabilities.

Larval Culture Techniques.

A variety of larval culture techniques have been developed because a single method is not always applicable in different localities. Each method is a variation of the basic process described by Loosanoff and Davis (1963).

In North Carolina, clam larvae are raised in plastic dishpans, each with about 140,000 larvae, kept in a temperature-controlled, darkened room. No water changes are made or antibiotics added and about 50% survive through setting. Larvae are fed from mass cultures of *Nannochloris*.

In Virginia, Castagna uses a modification of Glancy's greenhouse method — the plastic greenhouse was built by Castagna's group for about \$2,500. Larvae are raised in covered 50 liter plastic pails at an initial concentration of about 1,000,000/50 l which is later dropped to 200,000/50 l by setting time. Three times weekly larvae are

washed, counted, and sorted according to size; sorting is facilitated by sifting through screens made from large diameter plastic pipe and cloth screening. Generally no feeding is necessary since the clarified water used for the larvae is rich in natural phytoplankton. This water, which has been passed through a "clarifier" — usually a modified cream separator which removes heavy silt particles from the water, is incubated for 48 or more hours under natural sunlight or fluorescent growth lamps before use. Occasionally it is necessary to feed larvae with known algal species. Antibiotics are not used but clarified water is run through an ultraviolet treatment unit before use.

Cultured or Non-living Foods

Comparative growth studies of larval clams using various uni-algal diets have received much attention but little has been done with juvenile clams. Walne (1970) examined the growth rate of juvenile clams produced by 13 different algal species with that produced by *Isochrysis galbana*. The diatom *Skeletonema costatum* produced 3.3 times as much juvenile clam growth as did *Isochrysis*; others comparing favorably with *Isochrysis* or even better were *Pyramimonas grossii*, *Tetraselmis suecica* and *Nannochloris atomus*.

Use of non-living foods in place of living phytoplankton for larvae and/or juvenile clams continues to be investigated by our laboratory and others. Chanley and Normandin (1967) evaluated a number of possible non-living foods. Our preliminary experiments with juvenile clams using starch, finely-ground cereals and finely-ground freeze-dried *Porphyra* and *Ulva* have so far been inconclusive. In addition to *Porphyra umbilicalis* and *Ulva curvata*, other sea-weeds that will be evaluated are *Codium dichotomum*, *Dasys pedicellata*, *Ectocarpus* sp., *Enteromorpha tubulosa*, *Gracilaria folifera*, *Padina vickersiae*, *Sargassum filipendula* and *Scytosiphon lomentaria*.

Use of waste heat from nuclear powered, electric-generating stations to stimulate growth of phytoplankton foods and clams in cold water areas has been attempted by a Long Island company. Use by the power company of toxic chemicals to clean their cooling pipes has precluded this use of a possible waste energy source.

Juvenile Clam Rearing.

Use of covered outdoor troughs with running saltwater for rearing clams following setting is well established. A sand substrate in tanks has been shown to increase growth about fourfold. Castagna can get clams to a 1.7 - 3.0 mm size in two months and to a 10 mm size in about four months. Bayer gets similar growth but notes that this can vary considerably from one area to another.

Aggregate Method for Growing Commercial-Size Clams from Nursery-grown Seed.

Castagna, who developed this method, now has about 14 planters applying this method; Bayer in North Carolina has one. The planting area must be protected from the wind and be exposed to a slow current; a soft mud bottom usually indicates such an area. A layer of crushed oyster shells or stone (aggregate) several inches in depth serves to protect clams from predators. Clams 1.7 - 3.0 mm in length are planted at a density of 25/ft² (1,000,000/acre) and in the Wachapreague area clams are ready for harvesting as "little neck" in two years. Survival varies from 35 to 95%, but in areas not protected by the aggregate, survival is less than 16%. Harvesting can be done by a hydraulic escalator dredge which would harvest the entire crop and replace the aggregate

on the mud substrate.

Conclusion.

Technology is available to cope with temperature and salinity problems in clam hatcheries. When natural phytoplankton and nutrient levels are high, the clarified water technique seems most useful. When these levels are low, mass cultures of rapid growth-producing strains of algae can be established with a minimum of effort. Physiological and genetic differences among clams of different areas are a problem and can only be overcome through more research and a better understanding of the available stocks of clams. Selected breeding for rapid growing and hardy strains has only begun.

Technical information is available for commercial hatcheries to be a possibility and now the aggregate method of planting nursery stocks apparently makes the commercial farming of clams an excellent probability.

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THE DEVELOPMENT OF CLOSED SYSTEM OYSTER CULTURE

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Recent interest and progress in aquaculture has made the oyster a prime candidate for controlled culture methods. Since commercial oyster production was primarily based on natural populations, the main approach in shellfish research was ecological (Korringa, 1952; Galtsoff, 1964). With the degradation of the environment, water quality has deteriorated to the point where successful production under natural conditions is seriously threatened in many areas. In view of increased pollution and in many cases inadequate management practices of natural resources (Merrill, 1971), it appears that emphasis in aquaculture will have to be placed on the development of enclosed, completely controlled environmental systems to maintain a viable industry. To accommodate this change from a hunt and search method to one emulating agricultural techniques, a premium on studying the biology of the oyster under artificial conditions must emerge. To a certain extent, some of this research has been conducted. An excellent summary of the history of pioneer workers in developing shellfish methodology for controlled and semi-controlled conditions was presented by Loosanoff (1971). People like Wells, Glancy, Korringa, Walne, and Imai, representing several countries, have provided many basic methods involving hybridization, out of season spawning, larval rearing, and nursery activities. In particular the research of Loosanoff and Davis (1963) has played a leading role in promoting the development of oyster hatcheries in the United States. Their initial impact was experienced in the New England areas and it has subsequently spread south and to the Pacific Coast. Matthiessen (1970) provided a review of oyster culture and the oyster industry including description of hatchery operations throughout the country. Certainly, members of the oyster industry have contributed many techniques and refinements that are commonplace today. More recent developments along these lines involve integrating the various components of biology, equipment, and facilities into one system. Admittedly some of these efforts

have been paper studies (American Cyanamid, 1969; Jones, 1969; Goodman, 1971) unsupported by actual research. Nevertheless, these papers have performed an important service in attempting to describe and define the parameters to be studied before a controlled environmental oyster culture system can be economically feasible. Goodman (1971) makes a strong and provocative case for a systems analysis approach to the problem.

Although our interest in systems analysis in planning a hatchery operation is not unique, our aquacultural research has stressed this approach to ultimately develop a controlled oyster culture system for production of commercial size oysters. More specifically we have developed and refined aquacultural techniques in the laboratory that can be tested in a demonstration project. In essence we plan to provide data for the parameters defined in paper studies. Moreover, past work has shown that hatchery operations must be performed at a scale larger than previously attempted if people expect to develop valid, real world cost estimates. The demonstration project is designed to provide a sound minimum level to determine the technical and economic feasibility of scaling a controlled hatchery process to commercial production. At the same time results from the project are expected to indicate the refinements necessary for an optimal process.

The relationship between the demonstration project and research subprojects may be analogous to spokes of a wheel to the hub. Each subproject develops basic aquacultural techniques. For example, culture methods, systems engineering, environmental engineering, and problems of nutrition relate to the demonstration project. The most promising techniques from each discipline like spokes of a wheel are arranged at the hub or demonstration project as a complete production process. This process will be tested under conditions that will allow for the prediction of economic feasibility and large scale problems. Since few aquacultural projects are completely refined, the research subprojects continue to

develop specific aspects of the production process. In turn, each subproject serves as the hub of focus of still other subcomponents. For example, there are several natural subcomponents that relate to culture methods; selective breeding and hybridization, conditioning for out of season spawning, spawning methods, larval rearing, larval setting, and growth from nursery size to commercial size. Correspondingly, each discipline has its own subcomponents which must be treated before that discipline can contribute to the demonstration project. This research is in progress.

The goal of the demonstration project involves the production of commercial size oysters using an optimal combination of closed and semi-closed system. The system will be flexibly designed to provide for production testing of other organisms as new target species evolve from our research.

The production scheme is based in large part on research generated by the University's aquacultural group. A brief outline of this scheme follows.

1. Initially two species of oysters (*Crassostrea virginica* and *C. gigas*) will be cultured and crossed to obtain desirable characteristics (survivorship, growth, disease resistance, shape, taste) of each under closed (or semi-closed) system aquaculture (*Menzel, 1971; Maurer, 1970a).

2. Conditioning for out of season spawning and spawning methods will follow; (*Loosanoff and Davis, 1963; Maurer and Price, 1968; Price and Maurer, 1971a, b).

3. Larvae will be cultured using a bulk culture running water system (Maurer, 1970b).

4. Cultch will be treated with setting stimulants in order to control setting densities (Keck, et al, 1971).

5. Larvae will be set on mini-floats in order to increase growth rates (Maurer, 1970c).

6. Spat will be fattened to market size on welded wire and be handled as infrequently as possible to reduce labor costs (Harmon, 1970a).

7. Spawning, rearing, and growing tanks will be designed, constructed, and operated on a closed system basis unless disease, failure of equipment and food supply, or other unforeseen conditions require the use of filtered, temperature controlled, Delaware Bay water (Harman, 1970b; Costello, 1970a).

8. Larvae and spat will be fed measured quantities of known algal strains while the diet of older oysters will be supplemented with measured amounts of corn meal (*Ukeles, 1971; *Dunathan, et al, 1969; Harman, 1970b). Natural phytoplankton will also be assessed if Delaware Bay water is used for feeding.

9. Water quality in closed system (and semi-closed system if closed system becomes impossible) culture tanks will be monitored to determine levels of salinity, temperature, oxygen, PH, CO₂, and nitrogenous by-products of metabolism. Water quality will be maintained at predetermined standards known to be conducive to good oyster health and growth (Harman, 1970c; Maurer, 1970d).

10. Records will be maintained of the cost of producing oysters using this system (Costello, 1970; Goodman, 1971).

11. A pilot shellfish hatchery has been designed based on data provided by the preceding investigators and the literature (Miller and Bertred, 1971).

12. Property acquisition for the demonstration project has been arranged in a former oyster depuration plant and renovation is in progress (CMS 1972).

When the closed system approach was initially proposed, many of us had serious reservations about accomplishing the goals. Three years of research has yielded sufficient progress to encourage additional study. Problems like disease, the development of an inexpensive substitute food for the oysters, the cost of pumping large quantities of temperature controlled water, still remain to be resolved. The economic feasibility of producing commercial size oysters in a closed system may not be accomplished by this project. The real value of the research lies in the future availability of tested closed systems that may be necessary to produce any shellfish resources in a hopelessly polluted environment.¹

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¹ Marine Biology Contribution No. 74. This research has been supported in part by the NSF Sea Grant Program, the National Marine Fisheries Service, and the State of Delaware.

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MARICULTURE EXPERIMENTS WITH THE BAY SCALLOP, *ARGOPECTEN IRRADIANS*, IN WATERS OF THE SEASIDE OF VIRGINIA¹

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Experiments to test the feasibility of utilizing present mariculture techniques to rear the bay scallop, *Argopecten irradians*, were initiated at the Eastern Shore Laboratory of the Virginia Institute of Marine Science in 1968. This species was chosen for the following reasons: it has a relatively high market value and good consumer acceptability; techniques for spawning and larval culture are known; it has a rapid growth rate and a short life cycle; new markets and more stable prices could be attained with dependable production attainable in a mariculture operation; technological development on similar species are adaptable to the bay scallop (i.e. mechanical shucking and eviscerating). Adults were collected from Hog Island, Swash, Metomkin, and Chincoteague Bays on the eastern side of the Delmarva Peninsula and from Bogue Sound, North Carolina. A total of 66 constituted the original spawning stock, but the program has since utilized three subsequent generations for spawning stock. The adults were conditioned in the laboratory by holding them in seawater of 18 to 21°C for four to six weeks. The gonadal development could be visually checked without damage to the animal. When the gonads appeared ripe, the animals were induced to spawn, both during and out of their normal spawning period. A thermal stimulus of 21 to 27°C was used to stimulate spawning. Individual scallops usually spawned eggs or sperm, although hermaphroditic spawning was not uncommon. Self-fertilized and cross-fertilized groups developed with equal success. The larvae grew to setting stage in 10 to 19 days. Various combinations of cultured algae and/or centrifuged seawater held in a greenhouse for 48 hours were used as food. Post-set scallops were held in plastic trays or plastic troughs in the laboratory for one week, then moved to outdoor tanks with flowing unfiltered

seawater. They remained there until they were about 10 to 15 mm in width, then moved to field experiments. Juvenile scallops were held in plastic-screened wooden floats or screen-enclosed pens in the field where they reached an average minimum market size of 50 mm in 6 to 12 months.

Depth and Density Studies.

Scallops are presently being held in screened wooden floats at four different depths: surface, one meter below the surface, and one and two meters above the bottom, and at four different densities; 100, 75, 50, and 25 per square foot to determine both the optimum depth and optimum density at which to hold bay scallops. Data collected so far show no large difference in growth at the four depths. Data from the density experiment indicate approximately the same growth at all densities up to 27 to 28 mm. From this size on there is a decrease in growth rate with each increase in density.

Present indications are that the bay scallop is amenable to mariculture.



PLATE 3

Scallops growing in wooden and plastic screen floats.

¹ Contribution No. 411 from Virginia Institute of Marine Science.

AQUACULTURE OF MOLLUSKS IN THE GULF COAST REGION

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Molluscan aquaculture can be an important industry in the Gulf coast region, but an inspection of on-going and planned work indicates minimal recent activity. Some improvements in traditional methods of oyster culture have been attempted in Texas, Alabama, Louisiana, and Florida, but there are only a few on-going operations dealing with rearing of other mollusks in the Gulf. Menzel (1971) reported the potential of clam farming in the Gulf region.

The lack of current activity is understandable when we consider that sizeable natural populations of mollusks in the Gulf and south Atlantic are not yet fully exploited. For example, in north-west Florida there are populations of sunray venus, *Macrocallista nimbosa*, still not fully utilized. Along the upper Florida west coast southern quahogs, *Mercenaria campechiensis*, are available in commercial quantities, but only a very small fishery is active.

With the aid of Dr. John Dupuy and Sam Rivkin of the Virginia Institute of Marine Science, we have successfully reared the calico scallop, *Argopecten gibbus*, from eggs spawned in the laboratory. As part of our calico scallop life history studies, a group of these laboratory reared scallops are being grown to mature animals. However, I see no present economic feasibility in rearing calico scallops commercially when large natural populations off Cape Kennedy and

in the Gulf are not yet fully utilized.

Molluscan aquaculture in the Gulf region may provide a very important link in the developing shrimp and marine fish farming industry. Use of laboratory methods described by Loosanoff and Davis (1963) allows the researcher to generate mass cultures of various molluscan larvae — many are ideal food for rearing larval shrimp and young marine fish. For rearing young stages of marine fish and in certain applications for rearing larval stages of freshwater shrimp, genus *Macrobrachium*, I suggest the use of larval forms of *Mulinia lateralis* or a similar mollusk (Calabrese, 1969). Larvae of such warmwater mussel forms as *Brachidontes exustus* or *Brachidontes citrinus* may also be useful to feed larval crustaceans and young marine fish.

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AQUACULTURE OF MOLLUSKS ALONG THE WEST COAST OF THE UNITED STATES

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Considerable progress has been made in the aquaculture of marine mollusks along the west coast of the United States. The principal shellfish under culture is the oyster. Studies are presently underway to determine the feasibility of culturing abalone and several species of clams.

In California, oysters are being grown in three principal areas; Morro Bay, from rafts; and Drakes Estero Bay and Humboldt Bay, from racks (Fig. 1). Oysters are also being grown on the bottom in Humboldt Bay and Tomales Bay.

The largest commercial shellfish hatchery along the west coast is located at Pigeon Point, Pescadero, California. Here, millions of cultchless oysters are produced and sold to commercial planters throughout the United States. Some abalone seed also are produced at the hatchery.

A new state marine laboratory has recently been built at Granite Canyon, just south of Monterey, California. Studies in the culturing of oysters and abalone have been initiated. At Moss Landing attempts are being made to utilize heated water from a power plant in the culturing of marine mollusks.

Aquaculture of marine mollusks is limited mainly to oysters in Oregon. Centers of production are Yaquina Bay and Tillamook Bay. In Yaquina Bay oysters are grown from rafts (Pl. 4, Fig. 2) and racks while in Tillamook Bay oysters are grown on the bottom.

A shellfish hatchery is located at the Oregon State University, Marine Science Center in Newport. The hatchery is partially supported by industry who purchase oyster seed produced at the Center.

In Washington, as in the other two west coast states, oysters are the principal shellfish species being farmed. Among the three west coast states, Washington is the leading producer of oysters with landings totaling 6.2 million pounds in 1970.

The majority of oysters are produced in Willapa

Bay and Puget Sound using bottom techniques. Cultchless spat are being grown in Willapa Bay in an "oyster house" and in trays suspended from a raft. Raft culture of oysters is being practiced by one company at Purdy, Washington.

Initially the west coast industry was totally dependent on the importation of Japanese oyster seed. In recent years an extensive program has been developed in Dabob Bay to produce seed oysters. Annually, thousands of shell strings are suspended from racks and rafts in the Bay. After setting, the seed is planted on private bottoms in Washington and California. At present only a small portion of Dabob Bay is being utilized for seed production, and more than likely the use of this area for seed protection will be expanded.

A large EDA project is now underway at Lummi, Washington. Two small ponds (one-acre each) and one large one (750 acres) have been built for culturing oysters in combination with salmon. A small shellfish hatchery is also located at the site.

There is a great potential for oyster aquaculture along the west coast at this time. For example, it has been estimated by the Washington Department of Fisheries that if 28% of the total surface area of Puget Sound was used for floating oyster culture, a sustained annual production of up to 6 billion pounds of meat may be possible. In order for production to reach these levels there will be a need for large quantities of seed oysters. It is unlikely that the Japanese will be able to meet this demand; therefore, expansion of the Dabob Bay seed area and possible hatchery produced seed will be necessary.

The future for abalone culture remains in doubt. At present it is a wild fishery dependent on natural setting. If this species is to be cultured, private leases of good growing areas would be necessary. These areas could be seeded with small abalone reared in hatcheries. Some seeding is now

being done along the southern Oregon coast, where abalone previously had not been found. Abalone grow at an extremely slow rate. It is possible that heated water from electric power plants could be used to speed up their growth.

Commercial clam culture is very limited on the west coast. The industry is small and most landings are the results of a sport fishery. A new geoduck, (*Panope generosa*) fishery has been initiated in Washington and several small leases have been given out by the state. Whether or not this species can be farmed is not known at this time. Aquaculture of clam species in the future may include the soft-shell clam, *Mya*

arenaria; the razor clam, *Siliqua patula*; common littleneck, *Protothaea staminea*; and the Japanese littleneck, *Tapes semidecussata*.

Considerable effort, both governmental and private, is now underway to develop and expand aquaculture practices. Problems related to multi-use of waterways and pollution will have to be faced and hopefully solved if aquaculture is to be successful. Although the population along the west coast has been increasing at an accelerated rate, many of the areas that are presently utilized for molluscan aquaculture are not as yet subjected to this pressure.



PLATE 4

FIG. 1. Rack culture of oysters in Humboldt Bay, California.

FIG. 2. Raft culture of oysters in Yaquina Bay, Oregon.

MOLLUSCAN AQUACULTURE IN BRITISH COLUMBIA

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The 15,000 miles of British Columbia coastline extends from latitudes 48°20' to 54°40' N and has many fiords and inlets which provide much protected water. Approximately 800 species of mollusks have been recorded from these waters but only six enter the commercial fishery and but one, the Pacific oyster (*Crassostrea gigas* Thunberg), is cultured.

One species of gastropod (of approximately 450), the British Columbia abalone (*Haliotis kamtschatkana* Jonas), is harvested commercially. The fishery is small (annual landings less than 20,000 lbs) and sporadic, and it is unlikely this species can be cultured economically in the immediate future.

Four species of clams are used commercially: butter, *Saxidomus giganteus* Deshayes; littleneck, *Protothaca staminea* Conrad; manila, *Venerupis japonica* Deshayes; and razor, *Siliqua patula* Dixon. The clam fisheries are not extensive, peak annual landings were about 3000 tons round weight but recently they have been less than half this amount. At present none of the species lend themselves to aquaculture operations because of the extensive populations of wild stocks, slow growth rate and low price. Increased use in the recreational fishery may, however, make clam aquaculture economically feasible in the future.

Molluscan aquaculture in British Columbia centers on oyster culture. Three species of oysters have been harvested commercially: the native, *Ostrea lurida* Carpenter; the eastern oyster, *Crassostrea virginica* Gmelin; and the Pacific oyster, *C. gigas*. The fishery began before the turn of the century with small landings of *O. lurida*, and landings gradually increased until, in 1939, they were 1000 tons, mainly *C. gigas*. Since 1963, annual landings have consistently been over 3000 tons, entirely *C. gigas*.

The native oyster occurs throughout the province and was harvested commercially as early as 1884. A small fishery continued for wild stock, since this species was never really cultured in our province. The fishery ended about 1930, and al-

though it commands a high market price, the slow growth rate and small size make mariculture of this species unlikely in the immediate future.

The eastern oyster was introduced into British Columbia about 1903 to both the mainland and Vancouver Island and introductions (mainly for re-laying) continued on the mainland until about 1940. No extensive resident populations became established and, except for one small population on the mainland, the species is no longer found in British Columbia.

Since 1940, the production of Pacific oysters has increased steadily from 21,700 gallons (868 tons round weight). In 1962, landings first exceeded 100,000 gallons (4,000 tons round weight) and have remained above this figure since (except for 1968 and 1970). The landed value has also increased steadily from \$36,784 in 1940, to a high of \$870,981 in 1967. Since 1946, the value has consistently been over \$100,000.

The Pacific oyster is an intertidal oyster which was first introduced into British Columbia about 1912 and is now found in a feral state throughout much of the Strait of Georgia. Virtually all the culture has been intertidal bottom culture on ground leased from the provincial government. Most operations are family enterprises and the majority of leases are under 20 acres.

Seed was imported annually from Japan beginning in 1925 and reached a high of 5400 cases in 1951. The seed was spread on the lease and harvesting occurred after three years; production from one case of seed is about 25 gallons of shucked meats (1 ton round weight). Annual production from an acre of oyster ground is approximately 300 gallons shucked meats (12 tons round weight).

In 1942 and 1958, extensive breeding of Pacific oysters occurred in the Strait of Georgia which altered oyster farming practices. Large quantities of oysters became available to oyster growers on much of the crown foreshore area of the Strait of Georgia and many growers began to harvest these wild oysters in addition to, or instead of,



Population of Pacific oysters (Crassostrea gigas) in Pendrell Sound, British Columbia.



PLATE 5

Rafts with suspended shell cultch used to catch Pacific oyster (Crassostrea gigas) spat in Pendrell Sound, British Columbia.

oysters from their leases. The necessity for planting seed was greatly reduced.

Because oyster breeding in British Columbia is not consistent, the industry had to rely on yearly importations of seed from Japan. With the discovery of consistent breeding in Pendrell Sound, which lies in the northeast corner of the Strait of Georgia, the importation of seed is no longer necessary. Due to peculiar oceanographic conditions, regular annual oyster breeding occurs here and since monitoring began in 1948, a commercial set has occurred in every year but one, 1954. The discovery and development of Pendrell Sound has not only ensured a steady supply of oyster seed within the province but has also permitted an oyster seed industry to develop, most of which is exported (Plate 5).

The British Columbia oyster industry is now faced with new difficulties and new culture practices must be developed if the industry is to prosper and expand. Although the province is relatively free of pollution, 40% of the leased oyster ground is closed because of it. In addition, renewal of oyster leases requires the consent of the upland owner which is becoming more difficult to obtain because much of the land now has a high real estate value. Furthermore, the amount of suitable intertidal oyster ground does not exceed about 2500 acres.

Several alternatives to the standard bottom culture are possible but one, raft culture, appears to be the most promising. This permits the culture of oysters in a three dimensional aspect and is potentially 1000 times more effective in presenting food to the animals per unit of area than ground culture. Furthermore, the coastline of British Columbia appears well suited for raft culture with its many fiords and inlets containing much rich protected water.

Two courses may be followed for raft culture in British Columbia. If breeding is early in Pendrell Sound and the spat about 25 mm in diameter at the time of collecting, then the seed may be re-strung on wire so it is about one foot apart and suspended directly on rafts. The oysters will be large enough for harvesting in the following fall, i.e. when 14 to 16 months old. If the seed is small at the time of collecting, then it is grown on seed ground for one summer, re-strung, rafted the following spring, and harvested in the fall of the second year. Hence, production may be obtained from raft culture in either one or two years.

Experiments in one area of British Columbia showed that in bottom culture, one case of seed yielded 25 gallons of shucked oysters (1 ton round weight) in three years. In contrast, a similar amount of seed when grown one year on a raft, yielded 40 gallons of shucked meats (1.6 tons), and when held one year on the bottom and one year on the raft, yielded 80 gallons of meats (3.2 tons). The yield per acre is about 25 times that of bottom culture.

Oysters have been grown on experimental rafts in many areas over the entire coast. Growth was fastest in the Strait of Georgia, but satisfactory in the northern area. However, the oysters would require two summers on rafts in the latter region before harvesting. Certainly oyster production in British Columbia could be greatly increased by raft culture. A conservative estimate of annual production from 1500 acres suitable for raft culture in the Strait of Georgia is between two and three million gallons of shucked oyster meats, (80,000 to 120,000 tons round weight).

Continued work in the field of molluscan aquaculture is needed and future research might include:

1. Breeding a Pacific oyster with a lighter mantle suitable for the half shell trade.
2. Control of the environment to extend the growing season and alternatively prevent gonadal development so the oyster has a high glycogen content for a longer period of time.
3. Breed a stock of Pacific oysters with a lower reproductive temperature.
4. Use of other species of oysters; e.g. the Chilean or New Zealand oysters which have short larval periods.
5. Culture of other species of mollusks; e.g. scallop or perhaps mussels to provide cheap food for high price fish (salmon).

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FEEDING IN *JANTHINA JANTHINA*

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ABSTRACT

The pelagic gastropod *Janthina janthina* visits our coast regularly. This delicate snail is a

voracious predator, capturing its prey with swift movements and devouring it completely. (A brief color movie of *Janthina* feeding was shown).

INTERTIDAL MARINE ANIMALS OF THE PACIFIC NORTHWEST — THE MOLLUSKS

A 16 mm motion picture in color with sound.
Introduced by Arthur H. Clarke, National Museum
of Canada, Ottawa, Canada.

CINEMICROGRAPHIC STUDIES OF CRAWLING BEHAVIOR IN LARVAL AND JUVENILE BIVALVES¹

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Observations of pediveliger larvae and newly metamorphosed bivalve mollusks have revealed distinctive patterns of motion and locomotion in different species. Using 16 mm cinemicrography I have recorded differences in crawling behavior of a number of common New England bivalves.

Pediveligers of *Zirfaea crispata* crawl with rapid, rhythmic, muscular movements of the foot. Gliding on the extended foot occurs generally at very short intervals between bursts of muscular activity. Crawling in this pholad species is similar to that seen in the closely related family, Teredinidae.

Hiatella arctica seems to be less rhythmic in its crawling movements than other bivalves observed. Possibly, with further study, if we use variable speed projection and frame-by-frame analysis, a greater degree of underlying rhythmicity will be discovered. Gliding and muscular activity are both evident in *Hiatella*. Crawling involves a well-defined portion of the lower surface of the foot between the anterior tip and the prominent "heel". The shell of young crawling individuals does not follow the foot but moves from side to side in a zigzag motion, as the foot traces a more nearly linear path.

Cerastoderma pinnulata crawls in a manner superficially resembling *Hiatella* but with much greater rapidity. There is little or no involvement of the foot's diminutive "heel" in crawling.

In *Anomia aculeata*, the shape of the foot is very much like that of *Cerastoderma*. However, crawling movements are vastly different. Extensive gliding is seen, followed by relatively weak

and slow muscular movements. Rhythmicity is not generally apparent.

Young *Tellina agilis*, less than 500 microns long, exhibit the ability almost instantaneously to expand the distal portion of the foot into a flattened oval disk. Crawling is rapid, rhythmic, and entirely muscular. This species also shows a change in the pattern of locomotion with increasing size and age. Individuals over 500 microns long develop a rippling and thrusting muscular movement not seen in younger specimens. This activity is combined with the expansion of the foot described above, which seems to become relatively less pronounced in older individuals.

Newly metamorphosed *Mysella planulata* crawl with a slow, precise movement involving a highly rhythmic bobbing of the shell on the anterior-posterior axis. The "heel" is prominent and is always in contact with the substrate as the animal crawls. Both muscular movements and gliding are important in the crawling of this species.

The locomotory activities described above, and which I have recorded on film, have already proved useful in preliminary sorting of living bivalves in plankton samples and collections of microbenthos. With observations of more species, crawling behavior could become a systematic tool for distinguishing numerous pediveliger and juvenile bivalves that are similar in shell morphology.

Furthermore, precise knowledge of natural behavior of marine animals may be important in detecting or assaying sub-lethal effects of toxicants in the sea. Such features as the rhythmic crawling of *Mysella* or the flaring of the foot in *Tellina* could be affected by low concentrations of pollutants damaging to neuromuscular coordination in complex organisms such as bivalve mollusks.

¹ This work was supported by a grant from the Office of Naval Research, Contract No. N00014-67-A-0298-0027 with Harvard University.

CINEPHOTOMICROGRAPHY: A TOOL IN BIOLOGICAL STUDIES

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If "a picture is worth a thousand words" when describing a mollusk shell, then a moving picture is worth a million when describing the activities of the living animal. Moving pictures have been used extensively in biological research for many years but only relatively recently has it been possible to take movies through the microscope and even more recently to make time-lapse movies of living microscopic or minute organisms. Today, though still rather expensive, the techniques and equipment are available which allow the biologist not especially trained in photography to record his observations on film.

Anyone who has attempted to study the embryology and development of invertebrates or the functional anatomy and behavior of minute organisms knows how tiring it is to spend long hours peering through the microscope. He also knows the difficulties and frustrations of simultaneously observing and recording events either in writing or on tape. We have been working on the larval development, behavior and settlement of bivalves, especially the boring and fouling species, for several years, making pictorial records with a 35mm still camera. These pictures have been useful, but we have found it difficult to describe the movements and behavior of the larvae in words. We have also found that when rechecking our observations or comparing the activities of different specimens or species, our notes were sometimes vague or lacking in some essential detail. Consequently we turned to moving pictures in order to make a continuous record that could be replayed as needed for analysis or comparison of the anatomy and activities of individuals or species.

Rapid movements such as the swimming of veliger larvae can be studied by means of slow motion photography, while time-lapse can be used to make a continuous record of slower movements such as the penetration of the wood by newly settled and metamorphosing pediveligers, a process which may require two to three days. Knowing the speed at which the pictures were taken (i.e. the number of frames per second, per minute or even greater intervals) it is possible to time precisely these events without having to sit over the microscope — the camera does the work. Moving pictures have been particularly useful in

studying the anatomy and metamorphosis of bivalve larvae, for they are nearly transparent and, when swimming or crawling, continually turn so that one sees them from all sides. This allows one to understand the movement of muscles, the function of cilia, the path of food through the digestive tract or the development of the gills for example, in a way never possible with fixed material. Movies are also an effective way to study and record the reaction of bivalve larvae or other planktonic organisms to changes in environmental conditions such as temperature, salinity or the presence of pollutants.

The equipment used in taking the stills and movies showing the life history of *Nototeredo knozi* (Bartsch) and *Lyrodus pedicellatus* (Quatrefages) is given for the benefit of those who might be interested in using these techniques. This work was done with the aid of a grant from the Office of Naval Research under Contract No. N00014-67-A-0298-0027 with Harvard University.

EQUIPMENT

Microscope

- Compound microscope — Leitz Laborlux — for larvae, etc.
- Dissecting scope — for close-up of siphons, etc.

Camera

- Leica 35mm — for stills
- Bolex H16-Reflex 5 — for movies — for use with the microscopes or with Pan Cinor Lens for large animals, etc.

Lighting

- Incident light
- 2 tungsten 3200° K. photoflood lamps — 500 watts
- Sage Instruments Superstrobe Model 500 — to synchronize with shutter of movie camera
- Sage Instruments specimen shielding shutter — for time-lapse
- Transmitted light
- Leica Ultrapak illuminator — for stills
- Sage Instruments Superstrobe — for movies

Exposure meter

- Microsix-L — for stills
- Sage Instruments Model 293 — for movies

HAMINOEA SOLITARIA SAY IN NEW YORK

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The opisthobranch *Haminoea solitaria* Say appears seasonally in many bays of Long Island, in sheltered areas that offer a silty-sandy substrate. Stations and date of appearance vary from year to year, but they have been found with their egg masses at and below the low tide line as early as June 14th and as late as October 13th. Usually the shells are white to colorless, with traces of orange periostracal thickenings in the evenly spaced spiral grooves that cover the body whorl. They generally range to 8 and 10 mm in height.

Breeding colonies were found at a station on the bay side of Jones Island in the summers of 1958, 1963, 1970, and 1971. In 1970 there was a particularly large colony. The shells reached 13 mm and practically all had a periostracum that ranged in color from ivory in the lightest specimens to orange-horn in the darkest. In August of 1967, at the same station, freshly dead specimens rafted ashore on seaweed had the horn-colored periostracum covering the shells except at the area of depression around the protoconch. They were of remarkable size, ranging from 15 to 20 mm in height. Dr. R. T. Abbott verified the identification as *Haminoea solitaria* Say, remarking, "They are the giant form from New York first named by Totten as *insculpta* in 1835. Soverby records it in 1868 from New York."

The animal of *Haminoea solitaria* is dark grey. It is quite extensible and, unlike some of the other opisthobranchs, can retract into its shell. Living specimens were collected for observation in 1963 and 1970, and each lot produced egg masses, in the following manner: A few seconds after the snail burrows into the substrate, a small "air hole" is made. Next the hole is seen to be enlarged and covered with a clear gelatinous material. Some time later the spherical egg mass is pushed above the surface of the substrate, the clear bubble having been filled with an egg string containing thousands of eggs. The egg mass is attached to the substrate by a ribbon-like mucous cord that may measure up to 35 mm. Most of its length is beneath the surface, and the egg masses bob about above the substrate like tiny tethered balloons.

Egg masses collected in the field measured 10

to 15 mm in diameter. The gelatinous outer wall of the sphere, ± 1 mm in thickness, is smooth and slick when freshly deposited. The individual cases, which contain the minute ivory eggs, measure 8 cases per mm. As the larvae develop the outer surface of the sphere first turns rough in spots, then layer by layer disintegrates to coincide with the time of hatching. At 80° to 84° F hatching began, in captivity, early on the third day after deposit; at 72° to 76° hatching was not until late in the third day. Hatching continued for from 36 to 48 hours and at completion nothing but a few shreds were left of the original sphere. (As water temperatures in the bays during breeding season range from 68° to 73° F, it is likely that there is a longer incubation period *in situ*.)

The veliger has two fairly small velar lobes with rather short cilia; the mass of the swimming animal does not extend beyond the width of the simple glassy nuclear shell. Veligers hatched in captivity lived less than three days. Specimens retrieved from the container were of two sizes and were considered as newly hatched and about two days old. The newly hatched, 1/10 mm, had operculums that filled the apertural opening to the rim of the shell; the two-day-old specimens, 1/8 mm, had shell growth on the body whorl that extended beyond the closed operculum. Dr. Harold J. Walter kindly examined specimens at over 150X and advised me that the veliger shells are totally sculptureless, and that there are no traces of punctuation on the adult shell.

A silty substrate appears to be an important factor in the successful deposit of egg masses. As the animals were transferred to progressively siltless substrates, sand grains would cling to the egg masses until in clean coral sand the weight of the particles was sufficient to hold the egg masses in the substrate.

(Representative samples of egg masses and of both adult and veliger shells and animals have been placed with the American Museum of Natural History in New York, the National Museum of Natural History in Washington, D. C., the Marine Biological Laboratory at Helsingør, and with Dr. Harold J. Walter of Dayton, Ohio, whose assistance is greatly appreciated.)

MOLLUSKS COINCIDENT WITH NORTH CAROLINA'S CALICO SCALLOP FISHERY

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An active and profitable calico scallop fishery existed off the coast of North Carolina during 1965-1967 and 1970-1971. Large beds occurred northeast and southwest of Cape Lookout in 60-100 ft depths. Several small beds between Cape Lookout and Drum Inlet were being fished in July 1971 after the catch from the large beds had diminished considerably. No commercial quantities of adult scallops were found during 1968-1969.

The Mollusca coincident with the 1965-1968 North Carolina Calico Scallop beds and catches are described by Porter and Wolfe (in press). One hundred eighty-two different Mollusca are enumerated and the following are new northern range records:

Modulus modulus (Linne), *Alabina cerithioides* (Dall), *Strombus alatus* Gmelin, *Bursa bufo* (Bruguere), *Aspella anceps* (Lamarck), *Murex rubidus* F. C. Baker, *Olivella adela* Olsson (?), *Ancistrostylis radiata* Dall, *Comus floridensis* Sowerby, *Siphonaria alternata* Say, *Pododesmus rudis* (Broderip), *Pseudochama radians* (Lamarck), *Tellina magna* Spengler, *Tellina punicea* Born, *Coralliophaga coralliophaga* (Gmelin), *Gastrochaena ovata* Sowerby, *Thracia morrissoni* Petit.

Collections from the 1970-1971 fishery added few new mollusks to the total known North Carolina fauna; however some species previously thought to be rare appeared in numbers. These included the following:

Amacea retifera (Dall), *Cymatium krebsii* (Morch), *Cymatium parthenopeum* (von Salis), *Bufo bufo* (Bruguere), *Murex leviculus* (Dall), *Coralliophila caribaea* Abbott, *Trigonostoma smithi* (Dall), *Comus sozoni* Bartsch, *Syntomodrillia moseri* (Dall). In June 1971, when fishermen started to fish slightly north of earlier beds, most of the above species ceased to appear but numbers of large *Pleuroploca gigantea* (Kiener) and small or medium-sized *Cassia madagascariensis* Lamarck were found.

An explanation as to why species found abundantly in the 1970-1971 fishery were not so in the 1965-1967 fishery is not clear. The fishery may not have been in the identical area as it was earlier. Local environmental factors before the 1970-1971 season may have been ideal for spawning, survival of larvae, and growth of juveniles, but less so before the 1965-1967 season. Periods of such conditions are not unusual off the coast of North Carolina for many marine species. Unusual hydrographic conditions off the southeastern Atlantic Coast caused wholesale drift of larvae from more southern spawning populations. The larval drift capabilities of the cymatiums are well known.

The paper by Porter and Wolfe is concerned mainly with macro-sized Mollusca. To gain an idea of micro-size mollusks occurring coincident with the Calico Scallop fishery, stomach contents from two samples of sea-stars, *Astropecten articulatus* (Say), approximately 100 individuals each, were examined under microscope in 1971. Wells, Wells and Gray (1961) suggested that the stomach contents of these sea-stars may reflect the faunal composition of their habitat. Sea-stars of the May 1971 sample, believed to have been taken from the bed east of Cape Lookout, had a maximum arm length which ranged 35-93mm ($\bar{X}$ = 60.0mm). Sea-stars of the June 1971 sample, believed to have been taken from the bed just west of Cape Lookout, had a maximum arm length which ranged 32-76mm ($\bar{X}$ = 54.5mm).

A total of 1210 mollusks representing 66 species was found in the May sample. The June sample had 3584 mollusks representing 70 species. Wells, Wells, and Gray (1961) sampling 124 *Astropecten* stomachs from a non-Calico Scallop producing area off Ocracoke, N. C., recorded 1379 specimens representing 74 species.

Species taken from the 1971 sea-star stomach samples and not previously recorded from the North Carolina calico scallop grounds by Porter

and Wolfe (1971) include the following (common species — 10 or more specimens per sample — are indicated by an asterisk): *Arene tricarinata* (Stearns), *Solariella* sp., *Tricola thalassicola* Robertson, *Alvania auferiana* (Orbigny), *Cyclostremella humilis* Bush, *Cyclostremescus trilix* (Bush), *Teinostoma cryptospora* (Verrill), *Vitre-nella terminalis* Pilsbry & McGinty, *Caecum cooperi* Smith, *C. pulchellum* Stimpson, *Meioceras cubitatum* Folin, *Triphora pulchella* (C. B. Adams), *Epitonium apiculatum* (Dall), *E. candeanum* (Orbigny), *E. championi* Clench & Turner, *E. multistriatum* (Say), *Balcis conoidea* (Kurtz & Stimpson), *B. intermedia* Cantraine, **Olivella bullula* (Reeve), *Trigonostoma smithi* (Dall), *Bullata* sp., *Cerodrillia simpsoni* (Dall), *Cryoturris citronella* Dall, *Drillia actinocyclus* Dall, **Mangelia oxytata* Bush, *Syntomodrillia moseri* (Dall), *Vitricythara metria* (Dall), *Odostomia gibbosa* Bush, *Orinella lochlini* Bartsch?, *Pyramidella crenulata* (Holmes), *Pyramidella* sp., *Turbonilla interrupta* (Totten), *Turbonilla* sp., *Acteocina candei* (Orbigny), *Micromelo* sp., *Philine sagra* Orbigny, *Pyrrunculus caelatus* Bush, *Rhizorus persimilis* (Morch), **Spiratella trochiformes* Orbigny?, **Nuculana acuta* (Conrad), *Crenella glandula* (Totten), *Codakia* sp., *Mysella* sp., *Cardita tridentata* (Say), *Crassinella lunulata* (Conrad), *Cerastoderma pinnulatum* (Conrad), *Macoma tenta* (Say), *Tellina versicolor* DeKay, *Semele nukuloides* (Conrad), *Pitar fulminata* (Menke), **P. morrhua* (Linsley), **Corbula contracta* Say, *Pandora inflata* Boss & Merrill, **Lyonsia hyalina* (Conrad), *Cardiomya costellata* Deshayes.

Species taken from the 1971 sea-star stomach samples are indicated in Table 1. Those species not previously recorded from the North Carolina Calico scallop grounds by Porter and Wolfe (1971) are specified.

Data suggests that the composition of the samples was not similar. A species overlap of only 14 to 18% between the 1971 samples and that recorded by Wells, etc. is indicated. Overlap between May and June samples was only slightly better (26%). The May sample had more gastropods than bivalves whereas in the June sample this was strikingly reversed. The disparity between numbers of specimens caught in the May and June samples for the following species was striking: *Natica pusilla* Say, *Acteon punctostriatus* C. B. Adams, *Nuculana acuta*, *Argopecten gibbus* (Linne), *Abra loica* (Dall), *Corbula caribaea* Orbigny, *Notocorbula operculata* Philippi, *Lyonsia hyalina*, *Cadulus carolinensis* Bush. Additional samples must be taken to better understand this variability.

The data for *Argopecten gibbus* is particularly interesting (0 specimens in May, approximately 3,000 in June). It is possible that *Astropecten* has a preference for young scallops and will thus selectively feed on them to the exclusion of other possible foods when the young scallops are present in quantity. The June sample may be the result of this, or, it may be a true indication of relative densities of different molluscan species in the fauna of the immediate area. It is possible that this kind of sampling may now provide another means for determining time and density of setting by the Calico Scallop.

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THE "SUPERSPECIES" *DIPLODON DELODONTUS*

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The species-complex of *Diplodon delodontus* (Lamarek) contains six specifically identifiable taxa.

Some authors considered these as "forms", clinal variations of an unique species, or synonyms of other known species.

The taxonomic units are

- Diplodon solistanus* (Orbigny), 1835.
- D. uruguayensis* (Lea), 1860.
- D. martensi* (Ihering), 1893.
- D. expansus* (Kuster), 1856.
- D. paulista* (Ihering), 1893.
- D. delodontus* (Lamarek), 1819.
- D. delodontus wymani* (Lea), 1860.

The species have defined areas of distribution from southern Brazil, Uruguay to northeast Argentina, in the rivers Paraná, Uruguay and other tributaries of La Plata River system.

Although not entirely sympatric, their ranges nevertheless overlap greatly. Therefore, any consideration of subspecies — except in the case of *wymani* — is useless.

Also, the treatment of those named species as ecological forms of a polytypic species is not supported by their habitats: different forms may occupy a single niche, or the same form may be found in different habitats.

The variations, which have been called "forms of reaction" or ecological forms, by previous authors, are individuals, or groups of individuals, resulting from cross-breeding.

Cross-breeding is not only highly probable: it is easily detected when the parental species of the hybrids are well recognized by prevalence of specific characters.

In the original descriptions and illustrations of the six species mentioned, we found a great percentage of characteristics of constant specific value.

The systematic confusion which prevailed in this group of naids was due to the fact that many revisions were made with scarcity of materials to corroborate such characteristics.

Hybridization is not uncommon in bivalves, being most likely to occur, and it occurs in naids on account of their system of reproduction.

Furthermore, the genetic constituency in a group of species of close relationship and common ancestry — which are the factors defining the concept of the "superspecies" as it has been applied in recent years — favors the possibilities of cross-breeding when two or more populations, within those species complex, overlap.

A "superspecies" is neither a special kind of species with taxonomic rank, nor referred with particular nomenclature, but a purely genetic concept which, if applied in pertinent cases, as in our present of the *Diplodon delodontus* complex, helps to clarify some taxonomic problems.

In the superspecies of *Diplodon delodontus*, the following results of cross-breeding have been detected by hybrids (individuals or lots representatives of populations) among the materials studied:

Hybrids:

$$\begin{array}{l} \text{Diplodon delodontus delodontus 6} \\ \hline \text{x solistanus } \text{, x d.wymani x uruguayensis } \text{,} \\ \text{x martensi } \text{,} \\ \hline \text{Diplodon uruguayensis } \text{, Diplodon expansus} \\ \hline \text{x martensi } \text{, x expansus } \text{, 3 x paulista} \end{array}$$

- (1) Identified as *D. wymani* in most collections.
- (2) Described as *Unio peculiaris* Lea.
- (3) Specimens in many collections labelled (Ihering's hand-writing) as *Unio guahybae* (nomem nudum) are probably these hybrids.
- (4) Hybrids of *D. uruguayensis* x *expansus* were given different specific names: *D. trivialis* Simpson, *Unio caipira* Ihering, *Unio fokkiesi* Dunker.
- (5) Numerous specific names given to these hybrids.
- (6) The "typical" form of *delodontus* agrees entirely with what Lea described as *Unio rudus*.

MAINTENANCE OF THE NAIAD *AMBLEMA PLICATA* (SAY, 1817) IN AN ARTIFICIAL SYSTEM

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In order to conduct an experiment using the naiad *Amblema plicata* (Say, 1817) it was necessary to find a way to maintain this mollusk in an artificial system for a long period of time. A preliminary study was conducted to compare various methods of maintaining naiads. Forty-two naiads were collected 10 June 1969 and put in a stationary well water system. Some were placed directly on the slate bottom of an aquarium and others were placed in a glass holder constructed to maintain the naiads in their natural position. During the following month, 14 naiads died. The water in the aquaria often had foam along the sides and those naiads held in the glass containers became sluggish and many gaped open. Therefore, on 21 July, the remaining 28 naiads were placed on the bottoms of aquaria in a continuous flow system using the same well water that fluctuated in temperature from 12.2 to 16.6°C. Six naiads were soon sacrificed for experimental purposes. The remaining 22 naiads lived for 2 months in these conditions and appeared to be siphoning normally. One death on 17 September was presumed to be caused by starvation and the green, planktonic algae *Golenkinia* sp. was added to the system. Green pseudofeces were seen coming from almost all the naiads within 2 hours. In the next 11 days, two more naiads died and more algae was added to the system. During the following 3 weeks (28 September to 19 October) algae was added every 5 or 6 days and no more deaths occurred. These observations indicated that *A. plicata* was using *Golenkinia* sp. as a food source and the preliminary experiment was terminated.

For experimental purposes, specimens of *A. plicata* were collected on 20 October 1969 and placed in the continuous flow system. Eighty-nine naiads were designated as control organisms. The

first death occurred on 14 November and starting then *Golenkinia* sp. was added to the system every 4 or 5 days during most of the experiment. Green pseudofeces were frequently seen. Three naiads were sacrificed weekly for experimental purposes and the sample size was continually decreased. However, 16 naiads survived for 5 months (17 March 1970). The long survival time was another indication that *Golenkinia* sp. was acting as a food source for *A. plicata*. Other investigators (Allen, 1914; Allen, 1921; Bovbjerg, 1957; Churchill and Lewis, 1924) do not mention *Golenkinia* sp. as a food source for naiads, and further experimental work will be needed to statistically test this hypothesis.

Another observation was made between 20 December 1969 and 1 February 1970 when the iron content of the water was high ranging from 0.3 to 0.8 mg/liter iron. During this time the naiads produced a dark red pseudofeces that looked like iron oxide, indicating that *A. plicata* may be able to precipitate and concentrate the ferric ion from water. Additional work must be done to confirm this.

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FRESH-WATER MUSSELS OF LAKE LBJ, TEXAS

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Lake LBJ, formerly called Lake Granite Shoals, has a surface area of 6,300 acres and is located in Central Texas on the Colorado River. Lake LBJ was completed in 1950, lowered by six feet in 1964, and drained in 1970, reaching its lowest level on October 1, 1970, with the remaining water at the approximate level of the Colorado River prior to lake construction in 1950. The Colorado River is 600 miles long and flows in a southeasterly course to the Gulf of Mexico. The drainage basin of the river is approximately 37,800 square miles including the principal tributaries of the Concho, Llano, Pedernales, San Saba, and Pecan Bayou. The San Saba and Concho rivers are tributaries of the Colorado River above Lake LBJ, and the Llano River is a tributary of the lake.

The most recent and complete listing of the naiads of Texas was by Strecker (1931). Most of Strecker's (1931) records for the Colorado system are from the Concho River or from the Colorado River in Travis County, 40 miles downstream from the lake.

This report is considered significant for the following reasons:

- 1) One rarely has the opportunity to view the naiad fauna of a drained lake. This gives a view of the numbers and kinds of naiads present in a way that no other collecting procedure can duplicate.

- 2) No study of the naiads of the Colorado River has been reported since Strecker (1931).

- 3) Strecker (1931) recorded only three species of naiads from the Colorado River at the site of this lake: *Amblema plicata* (Say), *Leptodea fragilis* (Rafinesque) and *Potamilus* (= *Proptera*) *purpuratus* (Lamarck).

- 4) The former name of the lake, Granite Shoals, clearly expresses the geologic nature of the area. Because of the large granite outcroppings and the sharp granite gravel in the river, this immediate area is judged as unsuitable for most naiads. The construction of this lake created numerous habitats suitable to

naiads as indicated by the increased kinds present in the lake.

Most of the lake front property is privately owned; however, five areas of access to the lake were obtained. Although this appears to be a small sampling area for a large lake, one should realize that once on the dry lake bed an unlimited footage of the lake becomes accessible.

The following species of naiads were collected from Lake LBJ on January 10, March 27, and April 3, 1971. All specimens were collected dead but exposed in their living position.

Arcidens confragosus (Say). This is the western-most record for this species in the Colorado River with the previous record (Strecker, 1931) at Austin, Travis County, 40 miles downstream.

Anodonta grandis forma *grandis* Say. Specimens measuring 120-130mm were abundant near the dam but were scarce at other sites. No immatures of the form *grandis* were obtained from the lake.

Anodonta grandis forma *stewartiana* Lea. Valentine and Stansbery (1971) placed *stewartiana* as a form of *A. grandis* as did Strecker (1931). This is probably correct, but I observed no intergrades of the form *stewartiana* with the form *grandis* in this lake. The form *stewartiana* was common in quiet, shallow areas of the lake where numerous immatures were obtained. The presence of the forms *grandis* and *stewartiana* in the same lake with no apparent intergrades and the presence of the immatures of *stewartiana* form only indicate that this taxonomic problem needs further study.

Anodonta imbecilis Say.

Amblema plicata (Say). These large shells having high umbos with few ridges on the posterior slope are judged to be the form *peruviana* (Lamarck).

Quadrula quadrula (Rafinesque). Lake LBJ specimens, as with most South Texas forms, have more pustules on the umbo than specimens from the Mississippi drainage.

Quadrula pustulosa (Lea). One specimen was recovered having two pustules on the lateral slope. This is consistent with most of the Texas *Q. pustulosa* in having few pustules.

Leptodea fragilis (Rafinesque).

Potamilus (= *Proptera*) *purpuratus* (Lamarck).

Toxolasma (= *Carunculina*) *parva* (Barnes). Only one specimen was recovered.

Cyrtonaias grandensis (Conrad). This is *Lampsilis tampicoensis* Lea as listed by Strecker (1931). In Texas, this species is highly variable in size, color of nacre, and color of the periostracum. This was the most abundant species of naiad in Lake LBJ with most specimens having a black periostracum and a deep purple nacre.

Corbicula manilensis Philippi. Large popula-

tions occurred at two of five sites. All specimens were judged to be less than three years old which indicates a recent appearance in the lake for the Asiatic clam.

Prior to draining, Lake LBJ contained ten species of the family Unionidae and one species of the family Corbiculidae. The presence of ten unionid species shows a significant increase from the three species recorded by Strecker (1931) for this specific area of the Colorado River. This is the first record of the Asiatic clam, *Corbicula manilensis*, in Lake LBJ and in the Colorado River.

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SYMPATRIC SPECIES OF *ELLIPTIO* IN NORTH CAROLINA

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In 1834 Conrad named *Unio raveneli* from the Wateree Canal, South Carolina. It was collected in company with *Unio congaraea* Lea, 1831, in the same waters by Conrad's declaration. These two species both belong to the section *Cunicula* Swainson, 1840 of the genus *Elliptio* Rafinesque, 1819. By anatomy, glochidia, and reproduction — including parasitism on gills of host fishes — they are proven to belong to the subfamily Ambleminae s.s., of the family Amblemidae Rafinesque, 1820.

Examination of the North East Cape Fear River, about 2 miles west of Chinquapin, Duplin County, North Carolina, on July 11, 1970, showed these two species living together, just as Conrad had recorded them one and a third centuries ago. 39 males and 25 females of these mussels are *Elliptio congaraea* Lea, 1831 (Trans. Am. Phil. Soc., 4 : 72 : 6 : 4), of which *Unio icterinus* Conrad 1834 (New Freshwater Shells U. S., p. 41 : 6 : 15) is a synonym. *Elliptio congaraea* is more quadrate and much smoother in general appearance than is *E. complanata* Lightfoot, 1786. Its ecological preference in the North East Cape Fear River is for sandy bottoms, in which it burrowed completely below the water surface.

The second species, with a more elongate shell, duller periostracum, and of greater proportionate diameter, was more abundant in the muddier bottoms closer to the river bank. There were 9 males and 15 females in this sample of the species named *raveneli* Conrad (New Freshwater shells U.S., p. 39 : 6 : 4). *Unio confertus* Lea, published later in 1834 (Trans. Am. Phil. Soc., 5: 103 : 16 : 47), from the same Santee River System, is a synonym of *raveneli* Conrad.

When these shells were cut open, and the animals examined, it was found that all but three (12 out of 15) females of *raveneli* were gravid with eggs in the outer gills, on the date of collection, July 11, 1970. This was in direct contrast to the 25 females of *congaraea*, none of which were gravid on this date, with either eggs or glochidia in the gills. The discovery that *Elliptio*

congaraea and *E. raveneli* reproduce at different times, proves their specific distinction as continuing biological species that are sympatric. It corroborates Conrad's judgement of them as separate species when he named *raveneli* in 1834. The widespread *Elliptio complanata* was not found with *E. congaraea* and *E. raveneli* near Chinquapin in the North East Cape Fear River on July 11, 1970, although it is known to live in this river system.

Also in the Cape Fear River System, and in Lake Waccamaw, there is a third member of the *Elliptio angustata* (*producta*) group, that was first named *folliculata* Lea in 1838. This even more elongate and narrow *Elliptio* species is stretching out in the direction of the extremely longest and most narrow *Elliptio shepardiana* Lea of the Altamaha System. *Elliptio folliculata* lives alongside *E. raveneli* Lea, and *E. waccamawensis* Lea, 1863, in the sandy shallows of Lake Waccamaw. (see: Wildlife in North Carolina, Vol. 35, No. 4, April 1971, pp. 10 - 12.) This corroborates earlier records in the United States National Museum.

In the Potomac River System, *Elliptio complanatus* Lightfoot, and *Elliptio angustata* Lea, 1831 (+ *producta* Conrad, 1836) are living side by side in sandy silt, silt, or clayey bottoms.

A search for further sympatric species observations led to Ortmann's (1913, p. 319) listing of three species from the Rappahannock River of Virginia, *E. complanata* Lightfoot, *E. angustata* Lea, (+ *producta* Conrad) and *E. lanceolata* Lea, 1828. I know the latter two are sympatric, because I collected them living side by side in the Hazel River of the Rappahannock River System in 1934.

I found two *Elliptio* living together in the Tar River, August 26, 1966 at the route 64 bridge, 1 1/2 miles west of Spring Hope, North Carolina. In addition to 26 living *Elliptio complanata* Lightfoot and 14 living *E. raveneli* Conrad, there were dead shells of both *E. angustata* Lea and *E. lanceolata* Lea collected in the same 50 yard stretch of the Tar River at that time and place. In other words, there are 4 sympatric *Elliptio*

species in the Tar River System.

If you question what *Elliptio raveneli* Conrad is like — that is the only *Elliptio* species that was collected alive from the muddy shore of University Lake, west of Chapel Hill, August 24, 1966, along with the pygmy mussel, *Toxolasma pulla* Conrad, 1838. It did not surprise me to learn that *Unio pygmaeus* Lea, 1852 is a synonym of Conrad's name.

The entire Cape Fear River System includes five sympatric species of *Elliptio* living in these waters: *E. complanata*, *congaraea*, *raveneli*, *angustata*, and *folliculata*.

This story of sympatric species of one genus is not unique in North American Amblesininae. I believe Dr. Stansbery has collected five *Pleurobema* species in the same mussel bed of the Green River of Kentucky. Apparently Rafinesque also originally collected three of them together in the Ohio River, 150 years ago. These five are: *Pleurobema clava* Lamarck 1819 (+ *mytiloides* Rafinesque, 1820); *P. obliquum* Lamarck, 1819 (+ *cordatum* Rafinesque, 1820); *P. obliquata* Rafinesque, 1820 (+ *pyramidata* Lea, 1834); *P. premorsa* Rafinesque, 1831 (+ *plenum* Lea, 1840); and *P. sintoxia* Rafinesque, 1820 (+ *solidum* Lea, 1838).

The commonest Lampsilinae species found living together in Wisconsin Rivers and Lakes are *Lampsilis luteola* Lamarck, 1819, and *Lampsilis cardium* Rafinesque, 1820. In the Ohio and Tennessee regions, the most striking example of even closer sympatry is the repeated recording of *Lampsilis ovata* Say, 1817 and *L. cardium* Rafinesque living together. The biological proof of their speciation is that they are distinct in shell, with different beak sculpture, and that each

exists alone in some places. Of the two, there is only *L. cardium* in any of the waters of Wisconsin known to me. In contrast, there is only *L. ovata* of Say in the New River of Virginia (Kanawha River System above the falls), and in the Potomac River System, above the fall-line.

The named "form" *cohongoronta* Ortmann, 1912 is a form of *ovata*, and has no direct relation to *cardium* of Rafinesque. *Lampsilis o. cohongoronta* has not replaced *Lampsilis cariosa* Say, which in the Potomac region is essentially a tide-water species. *Lampsilis o. cohongoronta* filled a void that was not previously filled by any *Lampsilis* species, or that was not collected in by any scientific worker for more than 200 years. What I used to think was *L. cariosa* from the Upper Potomac (and Shenandoah River) System, proved some weeks ago to be only the slightly dwarf form *cohongoronta* of *ovata* Say. There are no *L. cariosa* specimens known to me from the Potomac at any appreciable distance above the fall-line.

Sympatry is also known for the Family Unionidae. A couple of years ago, I personally collected two species of *Unio* in the same cut-off pond of the Danube Flood-plain, a little east of Vienna, Austria. Those two species had animals of different color, as described by the European authorities. Of the subfamily Anodontinae, the most striking sympatric example known to me is the occurrence of *Anodonta* (*Anodonta*) *imbecilis* Say, A. (*A.*) *couperiana* Lea, and A. (*Pyganodon*) *teres* Conrad, living together in the same bottoms in Greenfield Pond, Wilmington, North Carolina.

SOME OCCURRENCES AND ASSEMBLAGES OF AQUATIC OHIO MOLLUSCA

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This study, centered on my home town, began in 1951, but was pursued sporadically until 1964 when an effort was launched to account for every aquatic molluscan species at the locality here designated M1. Like this assemblage, that at M2 came under observation at the start of the study; it is thoroughly known, as is the assemblage at M3. Each remaining locality's mollusks are known on the basis of one or a few field trips.

Locality M1 constitutes the last 1.6 miles of the Stillwater River, where it joins the Great Miami River in Dayton. Upstream, it has an obvious current and gravelly shoals, but downstream, where there are extensive mud shoals, artificial modifications have made it almost pondlike. Beds of water willow (*Justicia*), leaf-litter in the shallows, and early-season scouring out of shoals are important in its molluscan ecology. The habitat is evidently abnormally eutrophic, although reportedly minimally subject to the generally severe water pollution in the region. Turbidity generally prevents seeing specimens in more than a few inches of water. Collections were mostly made by sieving sediments and feeling in mud with the hands.

H. van der Schalie identified the *Dysnomia*. D. H. Stansbery identified shells of *Lampsilis fasciola* and for *Actinonaias* his suggestion regarding a submitted shell is applied. F. Thompson confirmed hydrobiid identifications (excepting *Pomatiopsis*). H. Herrington identified some *Pisidium* (localities GR6 and MI), *Sphaerium striatinum* (MI, CT), and *S. fabale* (CT), and confirmed identifications of *S. sulcatum* (M7) and *S. transversum* (CT). Species discovered only as shells, listed by number in accord with the lists below, are 21, 32, 33, 37, 39, 46, 55-57, and 59. Abundance of the 39 species taken at M1, similarly designated, is suggested thusly: very abundant, 1, 4, 6, 9, 12, 17, 36; abundant, 2, 3, 8, 34; very common; 11, 16, 24, 30; common, 10, 23, 29, 35, 38; fairly common, 14, 19, 20, 26, 27, 31; uncommon, 7, 13, 15, 18, 22, 25, 32, 39; rare, 5, 21, 28, 33, 37. These species make up the first list, wherein symbols for

habitats listed afterwards indicate additional locality records.

1. *Campeloma integrum* (Say)-M8,GR7; 2. *Campeloma rufum* (Haldeman); 3. *Campeloma decisum* (Say)-M8,GR7; 4. *Amnicola limosa* (Say); 5. *Probythinella lacustris* (Baker); 6. *Cincinnatia integra* (Say)-M8; 7. *Pomatiopsis lapidaria* (Say)-M2,3,8,10,GR4,6,8,CK3,CH; 8. *Pleurocera canaliculatum* (Say)-M8; 9. *Goniobasis livescens* (Menke)-M6,8,11,GR7,CK1,CH,D1; 10. *Ferrissia fragilis* (Tryon)-GR8,D1; 11. *Ferrissia rivularis* (Say)-M8,CT; 12. *Laevapex fuscus* (Adams)-M8; 13. *Micromenetus dilatatus* (Gould)-M8; 14. *Helisoma trivolvis* (Say)-M2,3,5,6,GR3,CK2,D1, P, HC; 15. *Gyraulus parvus* (Say)-M2,3,6,GR1,CK1, D1; 16. *Lymnaea humilis* (Say)-M2,3,6,8-10,GR1, 6,CK1,3,D1,CT; 17. *Physa heterostrophia* (Say)-M4,6-8,11,GR1,7,CK1,CH,D1,CT,GU,L; 18. *Physa gyrina* (Say)-M2,3,5,6,9,GR3,8,CK1,2,CT,HC; 19. *Fusconaia flava* (Rafinesque)-M8; 20. *Amblema plicata* (Say)-M8; 21. *Cyclonaias tuberculata* (Raf.)-M8; 22. *Elliptio dilatatus* (Raf.)-M8,GR7; 23. *Lasmigona costata* (Raf.)-M8,GR7; 24. *Anodonta grandis* (Say)-M6,8,11,GR7; 25. *Anodonta imbecillis* (Say)-M8; 26. *Alasmodonta marginata* (Say)-M8,GR7; 27. *Strophitus undulatus* (Say)-M8, GR7, D1; 28. *Actinonaias carinata* (Barnes); 29. *Carunculina parva* (Barnes)-M6,8,GR7; 30. *Lampsilis radiata siliquoidea* (Barnes)-M6-8,11, GR7,D1; 31. *Lampsilis ovata* (Say)-M8,11; 32. *Lampsilis fasciola* (Raf.); 33. *Dysnomia triquetra* (Raf.)-M8,GR7; 34. *Sphaerium striatinum* (Lamarck)-M6,8,GR7,D1,CT; 35. *Sphaerium fabale* (Prime)-M8,D1; 36. *Sphaerium transversum* (Say)-M8,GR7,CT; 37. *Pisidium dubium* (Say); 38. *Pisidium compressum* Prime-CK1,D1; 39. *Pisidium cruciatum* Sterki.

Additional localities, by county:

Montgomery County (M): -2, seasonally dry woods swamp adjoining M1 -3, ponded ditch draining storm sewer, across river from M2 -4, in cast-off "grit" from Dayton sewage plant -5, swampy pond, Northridge -6, Wyson's gravel pit, returning to wild state, west side of Dayton -7, Wolf

Creek, near M6 -8, Great Miami River, Taylorsville Dam, Vandalia -9, small rocky sewer-creek entering Stillwater River, Englewood Dam -10, seepage on shale outcrop, adjoining M9 -11, Twin Creek, Germantown Dam. *Greene* (GR): -1, polluted swampy creek, Wright-Patterson Air Force Base -2, muddy seepage pools around watercress -3, woods pond, Yellow Springs -4, seepage around limestone outcrop, Clifton Gorge, Little Miami River bank -5, rivulet, silted sand, wooded hillside, near Xenia -6, seepage, wooded hillside, near GR5 -7, Little Miami River, Spring Valley -8, pond-marsh adjoining GR7. *Clarke* (CK): -1, clear boggy creek, Medway -2, Great Cattail Marsh, Medway -3, small ditches near boggy ground, near Medway. *Champaigne* (CH): small clear creek, Cedar Bog, near Urbana. *Darke* (D): -1, Miller's Fork of Twin Creek, Ithaca -2, among *Calamus*, small intermittent oxbow of D1. *Clinton* (CT): Lytle Creek, near Wilmington. *Pike* (P): Pike Lake, near Bainbridge. *Hamilton* (HT): small lake, Sharon Woods, Sharonville. *Guernsey* (GU): ditch-creek, east of Cambridge. *Shelby* (S): in rotting log, isolated woods pool, near Ft. Loramie. *Hancock* (HC): vernal woods pools, near Van Lue. *Ottawa* (O): grassy swale-ditch, adjoining cattail marsh, west of Port Clinton. *Erie* (E): foul muddy

ditches, Cedar Point, Sandusky. *Lorain* (L): pools on limestone ledges, creek bed, east of Lorain.

Further species, with finds indicated by symbols for the above localities:

40. *Valvata tricarinata* (Say)-CK1; 41. *Viviparus malleatus* (Reeve)-E; 42. *Viviparus georgianus* (Lea)-HT; 43. *Marstonia lustrica* (Pilsbry)-CK1, CH; 44. *Pomatiopsis cincinnatiensis* (Lea)-M3, GR8; 45. *Planorbula armigera* (Say)-M5, GR8, HC; 46. *Planorbula exacuus* (Say)-M5; 47. *Planorbula umbilicatellus* (Cockerell)-M2; 48. *Helisoma anceps* (Menke)-M6-8, 11, GR7, 8, D1; 49. *Lymnaea umbilicata* (Adams)-HC; 50. *Lymnaea parva* Lea-HC, L; 51. *Lymnaea columella* Say-P; 52. *Lymnaea catascopium* (Say)-M2, 5, GR2, CK1, 2, D2, GU, HC, O; 53. *Lymnaea caperata* (Say)-M2, GR8, CK2, O, L; 54. *Aplexa hypnorum* (Linné)-D2, HC; 55. *Quadrula quadrula* (Raf.)-M6; 56. *Plethobasis cyphyus* (Raf.)-M8; 57. *Pleurobema clava* (Lamarck)-GR7; 58. *Lasmigona complanata* (Barnes)-M11, GR7; 59. *Lasmigona compressa* (Lea)-M8; 60. *Alasmidonta calceolus* (Lea)-GR7, D1; 61. *Anodontoides ferussacianus* (Lea)-M6, GR7, D1; 62. *Sphaerium sulcatum* (Lamarck)-M7, GR2, CK1; 63. *Sphaerium occidentale* Prime-M2, GR8, HC; 64. *Sphaerium partumeium* (Say)-S; 65. *Psidium casertanum* (Poli)-M2, GR5, CK1, CT.

VAGABONDING FOR SHELLS — IN RETROSPECT

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This day, this month 47 years ago, I left Ann Arbor, Michigan with P. Sheldon Remington for a collecting trip in the rivers and streams of Kentucky, Tennessee, and Alabama. This 1924 expedition and its experiences have colored my life throughout the intervening years, even to this day. Shel Remington was my boyhood companion when we both lived in the Boston area. We spent many wonderful days together collecting in the Blue Hill and the Quincy quarries south of Boston during our formative years.

The 1924 trip was made when I was a graduate student at the University of Michigan. It was sponsored by Bryant Walker, a Detroit lawyer, and Calvin Goodrich, an editorial writer for the Toledo Blade, and later Curator of Mollusks at the Museum of Zoology, University of Michigan, Ann Arbor. In essence, our trip had two main objectives. One was to make two or more collections from the Green, Cumberland, and Tennessee Rivers in Kentucky and Tennessee. The purpose of this was to determine, on the basis of the material and number of species collected, which of the rivers would be selected for a more detailed survey in the years ahead. Dr. Walker selected the Green River and two trips were made, one in 1925 with Carl Erlanson, a graduate student in Botany at the University of Michigan. This trip covered the upper reaches of the Green River as well as down stream as far as Mumfordsville, Hart County, Kentucky. In 1927, associated with Dr. Peter Okkelberg, Professor of Zoology, University of Michigan, we started from near Mumfordsville and continued collecting down stream to Rochester, Butler County, Kentucky. On both of these trips we collected as many tributary streams as possible.

The purpose of the second part of the 1924 expedition was to redo the trip made in 1853 by J. G. Anthony, then of Cincinnati, Ohio¹. Anthony, an ardent student of freshwater mollusks, made a walking and stage coach trip from Cincinnati, Ohio through Kentucky, Tennessee and south as far as Macon, Georgia. Unfortunately Anthony did not keep a log of his trip and as he worked up his material he became aware of errors in the

localities so in his published reports cited only the state for most of his new species². This led to many uncertainties concerning his species, most of which were in the very complex family Pleuroceridae.

It was a difficult job to work out his trip in its entirety, but he apparently went from Cincinnati to Louisville, Nashville, Knoxville, Chattanooga and on down to Macon, Georgia. He took several side trips and apparently many people gave him material. In his paper he also included material sent to him by his correspondents such as B. W. Budd, M. D. By following old stage coach routes and inquiring from the local people we were successful in collecting many of Anthony's original species, so that it is now possible to assign precise localities to them.

Pollution was bad in 1924 but nothing to what it is today. Then it was composed largely of silt with a small amount of commercial waste. Many of the rivers which we collected, then rich in material, are almost devoid of mollusks as well as most other forms of life, today. Though we did not realize it at the time, we were making history and preserving material that was to be lost to future generations. For example, we made twelve stations on the Clinch River and many of these are now destroyed by the impounded waters of flood control dams. This is true also of the Tennessee River.

A detailed account of our 1924 trip was published in the *Nautilus*³.

¹ See 'John Gould Anthony with a Bibliography and Catalogue of his species' by Ruth D. Turner, 1946, Occasional Papers on Mollusks, Museum of Comparative Zoology, Harvard University, 1(8): 81-108.

² J. G. Anthony 1854, 'Descriptions of New Fluvial Shells of the Genus *Melania* Lam. from the Western States of North America'. Ann. Lyceum of Natural History, New York 6:80-130.

³ Remington, P. S. and W. J. Clench 1925, Vagabonding for Shells. *Nautilus*, 38:127-143.

GREATER ADAPTABILITY OF FRESH-WATER MUSSELS TO NATURAL THAN ARTIFICIAL DISPLACEMENT

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Freshwater mussels are artificially displaced in their natural environment in many ways including simple removal from the substrate, being smothered by a substrate, and being disturbed in their substrate during harvesting of a mussel bed. The mussel may have the physical capacity to recover from these events by digging back in (or out), reorienting to the direction of current flow, and regaining a desirable water depth and type of substrate by migratory movement. But there is evidence that the mussel is more prone to accomplish these feats when the displacement is of natural rather than artificial origin. Animal behaviorists are learning that organisms utilize their abilities to surmount difficulties when certain response-triggering mechanisms, much more probably associated with naturally occurring problems, are present.

Smothering

The freshwater mussel presumably can extricate itself from a thin covering of sand or silt by employing the foot and valves (Barnes, 1955, 1962). It is conceivable, however, that an unnatural covering, a covering at an atypical season, or an otherwise artificial covering would not trigger a response mechanism for digging out even though the mussel has the physical means to do so. The results of the following laboratory experiments on mussel response to smothering as a form of artificial displacement indicate that the latter possibility occurs more often in practice. Mussels were placed on their sides in large battery jars, covered with sand, silt, or other substrate, and provided with about 1 foot of continuously aerated Lake Superior water at 16 C.

Detritus

On July 6, 1967, 9 *Anodonta grandis* were covered with 3 inches of detritus consisting of leaf, twig, and other loose material from a creek. A few mussels emerged each day until in 5 days all

had completely emerged. However, 16 *Fusconaia flava* were covered on July 18 and in 7 days, 2 *Fusconaia flava* were almost emerged, one-half way up, but 13 were on the bottom (10 dead). On July 14, 8 *Ligumia recta* were covered and in 4 days 3 were at least partly emerged but at least 3 were on the bottom.

Sand, Silt, Fine gravel

Other substrates (sand, silt, and fine gravel) were applied individually as smothering material and created similar fates for the animals as did detritus. Some species could emerge but more could not. Many animals finally died of suffocation on the bottom. The demonstrated failure of mussels to climb out of smothering conditions explains in part the devastating effects of dredging (van der Schalie, 1941: 308), channelization and quarry washing (Stansbery, 1970).

As an example of the difference to mussels between artificial and natural sand formation, Grier (1922) may be quoted:

"An old bed of "niggerheads" existing at Wild's Landing was found to be absolutely covered with sand deflected by the dams . . . the best collecting in this area was from the sand bars."

Methods of Harvest

Van der Schalie (1941) has commented that there has been "an excessive amount of mussel-shell gathering with the use of "apparatus" injurious to the mussel beds." He urges (1948) enforcement against the illegal practices of commercial hand-picking and forking because only the acceptable method with the crow-foot bar skins above the surface removing the larger, higher mussels and not removing the young ones, so necessary for replacement of the older stock. Dennis (1971) explains the damage to mussel beds by hand-picking or raking as a matter of removing too many shells for restocking to be possible. I suggest that an additional explanation

may be that brailing either removes a mussel entirely from the water or does not disturb it at all, leaving the substrate below relatively undisturbed. Forking and hand-picking on the other hand, with the kicking of the substrate, overturning of rocks, raking the substrate, and throwing back mussels too young for harvest, may amount to artificial displacement of the mussels not collected.

Removal from Substrate

On May 27, 1971, I placed 20 large male *Lampsilis ventricosa* on their sides at one location in 3 feet of water in a sandy area near the bank of the Eau Claire River, Wisconsin. On July 11, 19 of these mussels were found in the same 4 x 4 foot placement area (thus no migration). All were burrowed in except one almost on its side. All were oriented posteriorly upstream and 14 essentially parallel to the current flow.

However, earlier, in the late autumn, I left about 50 mussels (including *Lampsilis ventricosa*) on their sides in a 4 x 4 foot sandy area near the bank of the Eau Claire River and 3 months later the mussels were still on their sides except for 2 or 3 which had burrowed in. There was no migration from the placement area. Thus artificial dis-

placement, in this case displacement at an atypical season, was too extremely different from natural displacement for the animals to adapt to it.

Stansbery (personal communication) observed that mussels of certain species collected in summer and left on their sides in a pile for many weeks remained that way.

It may be speculated that part of the explanation for these experiences may be that certain species of mussels establish a partial domicile by growing into a shape which conforms to the particular microhabitat pressures and requirements at the location of the particular mussel. This follows the familiar experience of finding arcuate and even odd shaped specimens in areas with boulders, stones, and small patches of suitable sandy substrate. Such an older mussel would be less adaptable to displacement than a younger mussel.

The type or distinction shown here between artificial and natural imposition on the mussels may be involved in the unhappy circumstance that artificial river-lakes such as the large impoundments on the Tennessee River and elsewhere are so inimical to mussels but natural river-lakes such as Lake Pepin, Minnesota, or mussels-Shoals, Alabama, supported even more species and numbers of mussels than have large rivers.

THE MOLLUSK FAUNA OF THE NORTH FORK HOLSTON RIVER AT SALTVILLE, VIRGINIA

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A combination of extensive deposits of valuable chloride salts at the site of the headwaters of one of the richest freshwater fauna regions of the world has made Saltville, Virginia, a focal point of concern to biologists and water pollution authorities alike. For some 75 years the Olin Chemical Corporation has maintained a soda ash operation here with its chloride wastes going into the relatively small North Fork Holston River. The Holston River proper is one of the largest headwater tributaries of the Tennessee River which originally had an endemic fauna of 24 species of naiads alone. Unfortunately the chemical industry had been in operation for at least seven years before the first observations were recorded on its affects on aquatic life. Adams (1915:18), in his classic work on *Io*, notes that in August, 1900,

"At and below the alkali works the refuse flowing into the river has covered all the rocks and the bed of the stream with a whitish coating. Natives reported that fish had been killed in great quantities by this refuse. Had this factory been located a few miles farther upstream, *Io* would have become extinct in all this portion of the stream. Such influences show the importance of studying the animals of our streams before such pollution."

Adams had collected a fine series of *Io fluvialis* (Say, 1825) from the river above the polluted area. Collections in 1968 did not reveal the presence of *Io* at or anywhere above Saltville or at Holston, 20 miles downstream. The only pleurocerid snails found at that time came from above the Olin Corporation outfall. Abundant populations of *Oxytrema* (*Pleurocera*) *unciale* (Haldeman, 1841) and *Leptoxis* (*Anculosa*) *subglobosa* (Say, 1825) extended from within the Saltville city limits for miles upstream.

The first extensive collection of naiads made at Saltville proper was by Ortmann. He lists (1918:608) 15 species taken by himself in 1912 and cites 9 species collected there by Peterson in 1917 making a total of 16 different species. Dr. William J. Clench and I collected at Saltville in September

1968, and added two more unionid species bringing the list up to 18. Five species previously recorded (see table) were not found, however, indicating a fauna decreasing in species diversity.

Adams (1915:18), in his search for *Io*, made an effort to collect it at Holston in 1901. He found

"... the river apparently afforded an excellent habitat for *Io*. The water was shallow, about a foot deep, with an abundance of large rocks covered with a slimy algal growth and varied current from eddy to that of moderate swiftness. The water was clear, and yet no shells were found. I then examined the river for about a mile upstream ... no *Io* were found except an old weathered shell. I was told by a resident that occasionally the "alkali" refuse came down in such a quantity as to give the river a milky color. ... Unionids were present, however, as shown by the bivalves on the banks where they had been opened by raccoons or muskrats."

The naiad shells collected by Adams at Holston became part of the Walker Collection and were listed by Ortmann (1918:609). There were 14 species in this collection and efforts by Clench and myself to find any of these forms at Holston in 1968 failed completely. The North Fork at Holston still looked much the same as it did to Adams in 1900, but the only mollusks found were a few *Physa* sp. in a pool alongside the river. It appears that the entire river fauna has been eliminated from this site.

Recent attempts to collect the North Fork as far downstream as Rotherwood, only one mile above its mouth, did not reveal any living species of river mollusks, naiads or pleurocerids. Ortmann (1918:610) took 34 species of naiads at Rotherwood in 1913. It appears that the North Fork is devoid of mollusk life from Saltville as far down as the point where it joins the South Fork forming the Holston proper. What effect this badly polluted tributary has on the main stream is not known.

Just recently the Virginia Water Control Board established strict new standards which make the

SPECIES RECORDED

	Saltville, Va.				Holston, Va.		
	Ortmann, 1912	Peterson, 1917	Stansberry and Clench, 1968	Change	Adams, 1901	Stansberry and Clench, 1968	Change
Subfamily Anodontinae							
<i>Strophitus undulatus tennesseensis</i> Frierson, 1927	X	O	O	.	O	O	S
<i>Alasmidonta marginata</i> Say, 1818	X	O	O	.	O	O	S
<i>Alasmidonta viridis</i> (Rafinesque, 1820)	X	O	O	.	O	O	S
<i>Pegias fabula</i> (Lea, 1836)	X	X	O	.	X	O	.
<i>Lasmigona costata</i> (Rafinesque, 1820)	X	O	O	.	X	O	.
Subfamily Amblesinae							
<i>Fusconaia edgariana</i> (Lea, 1840)	O	O	1	+	X	O	.
<i>Fusconaia barnesiana</i> (Lea, 1838)	X	X	3	S	X	O	.
<i>Lexingtonia dolabelloides</i> (Lea, 1840)	X	X	1½	S	X	O	.
<i>Pleurobema oviforme</i> (Conrad, 1834)	X	X	3	S	X	O	.
<i>Elliptio dilatatus</i> (Rafinesque, 1820)	O	O	O	S	X	O	.
Subfamily Lampsilinae							
<i>Ptychobranchus fasciolaris</i> (Rafinesque, 1820)	O	O	1	+	O	O	S
<i>Ptychobranchus subtentum</i> (Say, 1825)	X	X	12	S	X	O	.
<i>Actinonaias pectorosa</i> (Conrad, 1834)	X	O	O	.	X	O	.
<i>Toxolasma l. lividum</i> (Rafinesque, 1820)	O	X	O	.	X	O	.
<i>Medionidus conradicus</i> (Lea, 1834)	X	X	15	S	X	O	.
<i>Conradilla caelata</i> (Conrad, 1834)	O	O	O	S	X	O	.
<i>Villosa iris nebulosa</i> (Conrad, 1834)	X	X	22	S	X	O	.
<i>Villosa vanuxemi</i> (Lea, 1838)	X	X	9	S	O	O	S
<i>Lampsilis ventricosa</i> (Barnes, 1823)	X	O	1	S	O	O	S
<i>Lampsilis fasciola</i> (Rafinesque, 1820)	X	O	4	S	X	O	.
Total Naiad Species Recorded	15	9	11		14	O	
Faunal Change in Numbers of Species				-5			-14

X = species present

O = none taken

+ = species added

. = species removed

S = same

continued operation of the Olin Corporation plant at Saltville economically unfeasible. Present plans are to phase out by December 1972 (Newcombe, 1971), but operations may stop before that time. Just how rapidly and to what extent the biota of the North Fork Holston can recover remains to be seen. The principle purpose of this paper is to summarize the changes which have occurred in the mollusk fauna up to the present time and to serve as a basis for comparison with such improvements as may hopefully occur in the not-too-distant future.

LITERATURE CITED

- Adams, Charles C. 1915. The variations and ecological distribution of the snails of the Genus *Io*. Memoirs National Academy of Sciences XII (II):1-92, 61 pls.
- Newcombe, Jack and Grey Villet 1971. End of a company town. Life 70(11):36-45, 14 pls.
- Ortmann, Arnold E. 1918. The nayades (fresh-water mussels) of the upper Tennessee drainage. With notes on synonymy and distribution. Proc. Amer. Philos. Soc. LVII (6):521-626, 1 map.

POPULATION CHANGES IN THE NAIAD MOLLUSK FAUNA OF THE LOWER OLENTANGY RIVER FOLLOWING CHANNELIZATION AND HIGHWAY CONSTRUCTION

Carol B. Stein

MUSEUM OF ZOOLOGY
THE OHIO STATE UNIVERSITY
COLUMBUS, OHIO 43210

During the 1950's and early 1960's the Olentangy River just below the Fifth Avenue Dam in Columbus, Ohio, supported large populations of a wide variety of native aquatic animal species, including many kinds of river mollusks. The bed of the river was stable, consisting mainly of gravel and cobbles in shallow riffles and runs between small islands of water-willow and flood plain trees, as shown in the top figure of plate 6.

Zoology students and faculty members of The Ohio State University (OSU), located nearby, frequently visited this site to study the various native species and to obtain specimens needed for research and classroom demonstration. More than 20 collections made here between 1956 and 1967 by Dr. David H. Stansbery, myself, and other OSU zoologists are now deposited in the mollusk research collections of the OSU Museum of Zoology.

Seventeen species of naiads (see table) are known to have been living in the Olentangy below the Fifth Avenue Dam as recently as the early 1960's. Four additional naiad species were found only as sub-fossil shells, indicating that they had been extirpated from this site before 1956.

As shown in the center figure, the river channel was greatly modified during the summer of 1968, when a new freeway was constructed above the river. All the islands and other irregularities of

the riverbed were eliminated, and the channel was graded to a uniform depth. Pillars were placed in the riverbed to support the new roadway. The height of the dam was increased approximately three feet.

In 1971, three years after channelization, the site was again searched for naiads. Two afternoons of collecting yielded only three living specimens: two *Anodonta imbecillis* and one *Anodonta grandis*. The only other naiad species which were found were *Strophitus undulatus* (one fresh shell) and *Lampsilis radiata luteola* (two fresh shells). All of the other naiad species appear to have been extirpated from this site. Those species which were found are among the few naiads which are able to live in the silt-bottom, quiet-water pool impounded by the dam. It seems probable that they were washed over the dam during a period of high water following the channelization.

Silt, diatoms, and filamentous algae now cover the rocks in the river channel below the dam. One small patch of water-willow, about two feet in diameter, has become established in the channelized section of stream. How long a period will be required for the re-establishment of a stable and diversified naiad fauna at this site is unknown.

SPECIES	BEFORE (1956-1967)	AFTER (1971)
Family UNIONIDAE		
Subfamily ANODONTINAE		
<i>Anodonta imbecillis</i> Say, 1829	X	X
<i>Anodonta grandis</i> Say, 1829	X	X
<i>Strophitus undulatus</i> (Say, 1817)	X	X
<i>Alasmidonta marginata</i> Say, 1818	X	O
<i>Alasmidonta calceolus</i> (Lea, 1829)	X	O
<i>Lasmigona costata</i> (Rafinesque, 1820)	X	O
Subfamily AMBLEMINEAE		
<i>Quadrula cylindrica</i> (Say, 1817)	S-F	O
<i>Amblema plicata</i> (Say, 1817)	X	O
<i>Fusconaia flava</i> (Rafinesque, 1820)	S-F	O
<i>Pleurobema coccineum</i> (Conrad, 1836)	X	O
<i>Elliptio dilatatus</i> (Rafinesque, 1820)	X	O
<i>Unio merus tetralasmus</i> (Say, 1830)	X	O
Subfamily LAMPSILINAE		
<i>Ptychobranchus fasciolaris</i> (Rafinesque, 1820)	X	O
<i>Actinonaias ligamentina</i> (Lamarck, 1819)	S-F	O
<i>Toxolasma parva</i> (Barnes, 1823)	X	O
<i>Villosa iris</i> (Lea, 1829)	X	O
<i>Lampsilis radiata luteola</i> (Lamarck, 1819)	X	X
<i>Lampsilis ventricosa</i> (Barnes, 1823)	X	O
<i>Lampsilis fasciola</i> Rafinesque, 1820	X	O
<i>Dysnomia triquetra</i> (Rafinesque, 1820)	X	O
<i>Dysnomia torulosa rangiana</i> (Lea, 1839)	S-F	O

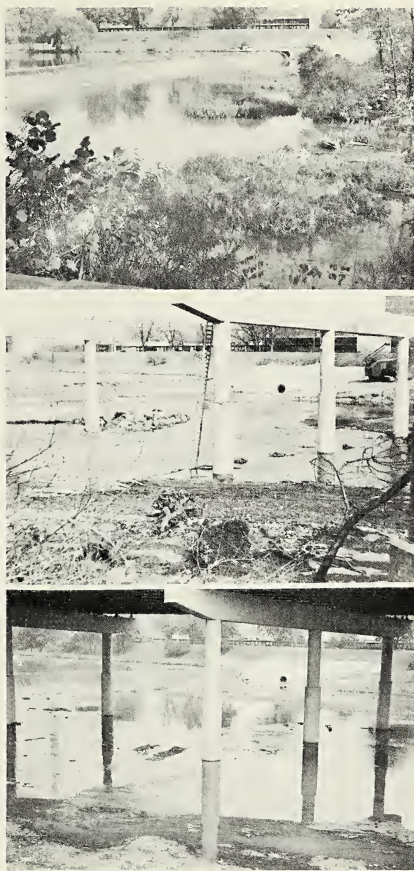


PLATE 6

The Olentangy River below the Fifth Avenue Dam in Columbus, Ohio. Top: in 1961, showing habitat conditions under which 17 species of naiads thrived. Center: in 1963, during highway construction and channelization work. Bottom: in 1971, three years after channelization.

REPORT OF AMU CONSERVATION COMMITTEE

Dr. Dolores S. Dundee presided in the absence of Mrs. Anne Spears, chairman; Mrs. Jeanne Whiteside served as secretary pro tem.

Dr. Marc J. Imlay read the President's Water Pollution advisory Board's annual conference Resolution IV: recommendations of the Bureau of Sports Fisheries and Wildlife:

1. To declare the Merrimac River, Missouri a wild river to prevent the Corps of Engineers from damming it;

2. To set aside the following rivers as sanctuaries: the Clinch in West Virginia, the Powell in Tennessee, and the Paint Rock in Alabama.

3. To provide funds for surveys in Texas;

4. To provide funds for publishing descriptions and making color films for public recognition of endangered species. Dr. Imlay also stated that work is required by shell clubs, individuals, and conservation groups to preserve rare and endangered species, e.g. the geoduck clam on the west coast.

Dr. David H. Stansbery reported that Senator Royce of Wisconsin had offered a bill to declare a one-year moratorium on funds for stream channelization. The bill was defeated in the Senate but will be offered again.

Dr. Imlay introduced Mr. Earl B. Baysinger of the Office of Endangered Species of the Department of the Interior who recommended that the AMU prepare a form suitable for the description of mollusks to aid in the identification by members of his office, giving the locality as well. He also suggested that the AMU set up a review committee to propose the names of endangered species. Such species will be entered in the Federal Register which must be referred to by other Federal Departments in planning their programs. However, the entering of species in the Register alone does not insure local protection; this can be done only by the states through legislation and enforcement, except on Federal lands. Mr. Baysinger also pointed out that the designation "rare and endangered species" is defective, since his office recognizes only endangered species, that is, those in danger of becoming extinct. The term "rare" refers to small popula-

tions at present safe from extinction because of isolation in difficult country, etc. They become "endangered" in the event of a natural or man-made catastrophe. Hence Mr. Baysinger suggested that only the term "endangered" be used.

Dr. Arthur H. Clarke asked if the AMU will lose its tax-exempt status should it engage in lobbying. Mr. Baysinger answered that much can be done by individuals and even organizations without the Internal Revenue Service declaring the organization a lobbyist. However, it is important to begin at the local level in town councils, county commissioners, etc., to prevent a potentially harmful project from getting started, since once such a project is beyond the preliminary planning stages, it is often too late.

Dr. Dundee appointed Dr. Imlay chairman of a subcommittee to work out the descriptive form suggested by Mr. Baysinger and to decide how these forms will be distributed to taxonomists and zoogeographers.

President Stansbery stated that the Executive Council of the AMU will take up requests for funds for the Conservation Committee in the budget. He also stated that the AMU can accept donations from individuals and clubs for this purpose.

In the general discussion, means of collating and disseminating information on endangered species were discussed. Collaboration with other groups such as the Audubon Society, League of Women Voters, etc, was proposed to plan preventive measures. We were also asked how we as shell collectors can undertake conservation. It was suggested that we change our attitude toward nature by discouraging not necessarily eliminating, live collecting by AMU members. The next edition of the AMU booklet on HOW TO COLLECT SHELLS, will be renamed HOW TO COLLECT AND STUDY MOLLUSKS and emphasis will be placed on making observations, studying life habits, etc. rather than indiscriminately collecting to please passing whims. A committee was set up to propose a revised code of ethics for the collector.

Jeanne Whiteside
Sec'y pro tem

THE AMERICAN MALACOLOGICAL UNION, INC. ANNUAL BUSINESS MEETING, JULY 19, 1971

President David H. Stansbery, presiding, called for a motion to waive reading of the minutes of the previous annual business meeting since an accounting had appeared in the Annual Reports for 1970. Motion made, seconded, carried.

The reports of the Secretary and the Treasurer were heard and approved. See following sheet(s) for details. The budget for calendar year 1972 anticipates receipts and expenditures of \$4,600, with \$3,200 of that amount for the printing of the 1971 Annual Report.

The Secretary reported on the Executive Council Meeting held July 18, 1971, and gave the following summary of matters considered: The format of the Annual Reports may be changed so that we will be able to get the best possible publication at the lowest possible cost. The title will be changed from Annual Reports to Bulletin. Because it is less expensive to print a smaller number of larger pages, the size of the pages of the Bulletin will probably be larger. *How to Collect Shells* will be revised before reprinting. Title is to be changed to *How to Collect and Study Mollusks*. Articles are to include emphasis on ecology and conservation. No action is to be taken on moving AMU's state of incorporation from California, a move that seemed desirable last year. It is possible that we will be better off as an unincorporated association. This will be studied further. The Legal Committee was asked to consider the limits of AMU activities in influencing legislation regarding endangered species. It was also asked to consider results of dropping our non-profit status. A number of new committees were created to study particular problems, and to report by next year. There are now ten committees — Annual Meeting Site, Auditing, Budget, Conservation, Constitutional Revision, History and Archives, Legal, Membership, Nominating, and Publications. The report of the Conservation Committee was reviewed by the Council. An open meeting of that Committee had been held on July 17. The Committee now has a budget for expenses, and

channels of communication are clearer. It was recommended that each member of the AMU consider conservation as his own personal responsibility, letting his conscience be his guide. The President announced that the next Annual Meeting will be in Galveston, Texas, starting July 10, 1972.

The Secretary read the report of the Nominating Committee and explained that some officers are now elected for several years. The following were nominated: President, Arthur S. Merrill; President-Elect, Dolores S. Dundee; Vice President, Harold D. Murray; Corresponding Secretary, for three-year term, Paul R. Jennewein; Councilors-at-Large, for two-year terms, Henry D. Russell and Carol B. Stein. The motion was made, seconded and carried that the nominations be closed. The Secretary was instructed to cast a unanimous ballot for the slate.

Under new business, the desirability of formulating an AMU Code of Ethics for collectors was discussed by the membership. Copies of TIDE LINES, a publication of the St. Petersburg Shell Club, were passed out, as a Code was printed in it. Mr. Jacobson said it does not go far enough to suit him. He would like to see a pledge that starts, "I will not collect live shells", but allows for exceptions as conscience permits. Miss Stein recommended that the Conservation Committee work on formulating a Code of Ethics and present information to the members at the next meeting or, preferably, prior to the meeting. Mrs. Beetle suggested that the school field trip is a good place to start to emphasize the importance of just looking, not taking plants or animals. It might be helpful to prepare a pamphlet for teachers, especially elementary school teachers, on how to conduct a field trip. This can be done by the AMU or by a shell club.

Dr. Stansbery turned over the gavel to incoming President Merrill, and the meeting was adjourned.

REPORT OF THE SECRETARY FOR 1970

As of January 1, 1971, the membership of the AMU was 823. The following is a tabulation of membership by category, and comparison with the previous year.

	1/1/71	1/1/70
Individuals	510	514
Individuals under		
Family Membership	235	185
Corresponding Members	37	28
Honorary Life Members	9	8
Clubs	32	37
Total	823	764

Since year-end, several of the clubs that had been dropped for non-payment of dues have been contacted, and three of them have renewed membership. About 100 names were dropped in 1970 for non-payment of dues. These were more than compensated for by new members and by members who added their spouses to the membership rolls.

Respectfully submitted, Marian S. Hubbard, Recording Secretary.

REPORT OF THE TREASURER FOR THE FISCAL YEAR ENDING DECEMBER 31, 1970

Check Book Balance, January 1, 1970 2,294.27

Receipts

Memberships: Regular	2,604.25	
Corresponding	149.25	
Shell Clubs	188.00	2,941.50
Sales: How to Collect Shells	401.15	
Bulletin (back issues)	137.45	
Rare & Endangered Species	16.10	554.70
Proceeds of Key West Meeting		771.34
Page Charge to Authors		80.00
Interest on Bonds		158.55
Miscellaneous		2.69
TOTAL RECEIPTS		4,508.78

Total cash to be accounted for 6,803.05

Disbursements

Printing: Annual Report	2,604.16	
Newsletter	172.60	
Miscellaneous	85.03	
Rare & End. Species	201.00	3,062.79
Postage		229.51
Office Supplies — Secretary & Treasurer		57.87
Bank Charge		25.37
Secretary's Expenses — Annual Meeting		253.78
Office Expenses — Secretary & Treasurer		113.51
TOTAL OPERATING EXPENSES		3,742.83
Deposit in 5% savings account		1,000.00
TOTAL DISBURSEMENTS		4,742.83
Checking Account Balance, December 31, 1970		2,060.22
Total cash accounted for		6,803.05

Savings Account B14592, Colonial Federal Savings & Loan Association

Balance, January 1, 1970	663.30
Interest for year	47.94
From Checking Account	1,000.00
Total Balance	1,711.24

Recapitulation of Assets, December 31, 1970	
Cash in Checking Account, Girard Trust	2,060.22
Treasurer's Petty Cash	10.00
Secretary's Petty Cash, transferred from Margaret Teskey to Marian Hubbard	100.00
Savings Account	1,711.24
Savings Bonds — Girard Trust	3,000.00
Total Assets	6,881.46
Allocated to Life Membership Fund	1,470.88
AMU Net Worth, December 31, 1970	5,410.58
Changes in Capital Account:	
AMU, Capital Account, Jan. 1, 1970	4,596.69
AMU, Capital Account, Dec. 31, 1970	5,410.58
Net Increase in Assets, 1970	813.89

Respectfully submitted, Bernadine B. Baker, Treasurer

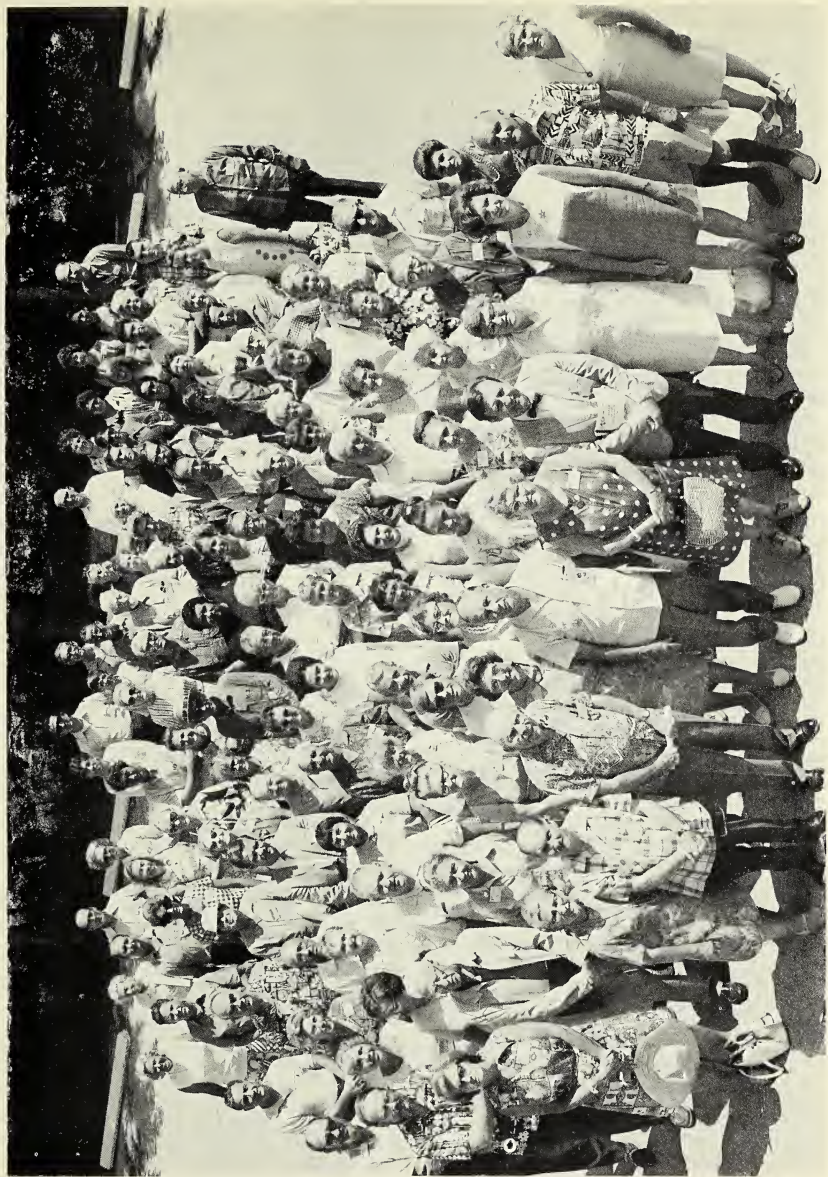
Audited February 5, 1971 by R. Tucker Abbott and Russell H. Jensen

THE AMERICAN MALACOLOGICAL UNION, INC. THIRTY-SEVENTH ANNUAL MEETING

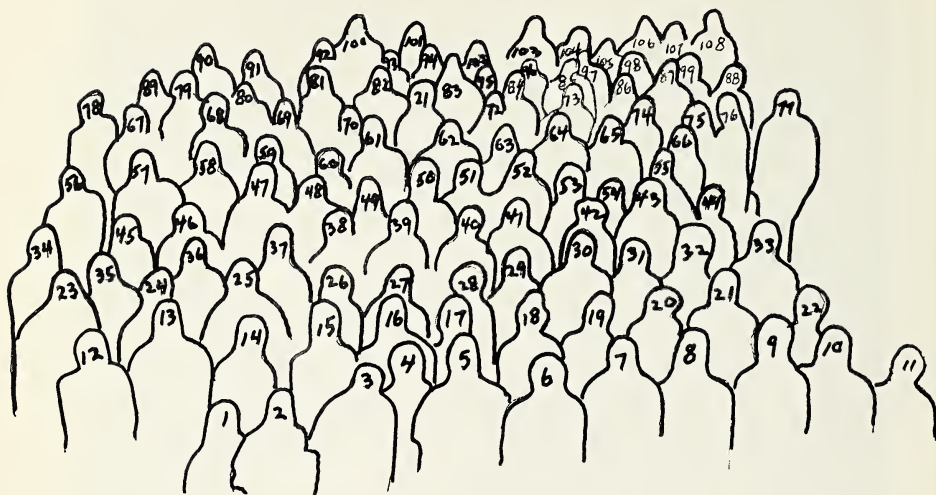
MEMBERS AND GUESTS IN ATTENDANCE:

- Mr. Kirk Anders, Ft. Lauderdale, Fla.
 Mrs. Bernadine Baker, Havertown, Pa.
 Mr. John Baker, Patrick A.F.B., Fla.
 Mrs. Wilma Baker, Sarasota, Fla.
 Mr. Earl Baysinger, Washington, D.C.
 Ken Bazata, Lincoln, Neb.
 Mrs. Dorothy Beetle, Newport News, Va.
 Jerome M. Bijur, Naples, Fla.
 Mr. & Mrs. Alvin Bippus, Toledo, Ohio
 Mrs. Morley Bishop, Akron, N. Y.
 Miss Shirley Bishop, Akron, N. Y.
 Mr. & Mrs. Howard Blum, Pompano Beach, Fla.
 Mrs. Hollis Q. Boone, Houston, Tex.
 Mrs. Jane Brooks, Fort Pierce, Fla.
 Michael Castagna, Wachapreague, Va.
 Dr. & Mrs. Arthur Clarke, Manotick, Ont., Canada
 Dr. William Clench, Dorchester, Mass.
 Mrs. Juliette Compitello, Bethesda, Md.
 T. J. Costello, Miami, Fla.
 Dr. John Culliney, Cambridge, Mass.
 Dr. Dolores Dundee, New Orleans, La.
 Lt. Col. Corinne Edwards, Coconut Grove, Fla.
 Dr. & Mrs. John Ferguson, Chapel Hill, N. C.
 Mrs. Kleinie Fieberg, Wilmette, Ill.
 Mr. & Mrs. E. Flynn Ford, Ft. Lauderdale, Fla.
 Dr. & Mrs. Lake Fowler, Galveston, Tex.
 Mrs. Susan Gallagher, Treasure Island, Fla.
 Dr. Carl Gugler, Lincoln, Neb.
 Mr. & Mrs. M. T. Harris, Jacksonville, Fla.
 Mr. & Mrs. Edwin Hicks, Eau Gallie, Fla.
 Mr. & Mrs. Wayne Holiman, Edinburg, Tex.
 Mrs. Marian Hubbard, Seaford, L. I., N. Y.
 Mr. & Mrs. Mart Hulswit, New York, N. Y.
 Mrs. Ruth Hunkins, Englewood, Fla.
 Dr. Marc Imlay, Duluth, Minn.
 Mr. & Mrs. Morris Jacobson, Rockaway, N. Y.
 Mrs. Beth Johnson, North Myrtle Beach, S. C.
 Mrs. Kenneth Johnson, Raleigh, N. C.
 Mrs. Hessie Kemper, St. Louis, Mo.
 Mrs. Lucia King, Ft. Myers, Fla.
 Mrs. Florence Kuczynski, St. Petersburg, Fla.
 Sophie Kuczynski, St. Petersburg, Fla.
 Dr. Edward La Roe, Miami, Fla.
 Judge & Mrs. Benjamin Lencher, Pittsburgh, Pa.
 Mr. & Mrs. K. R. Lewis, Merritt Island, Fla.
 Mr. & Mrs. Albert Lindar, Chicago, Ill.
 Mr. & Mrs. Glen Long and family (2)
 Mrs. Mary Long, Sonora, Cal.
 Mr. & Mrs. Walter Lowry, Raleigh, N. C.
 William Lyons, St. Petersburg, Fla.
 Mrs. Cornelia McInnes, Raleigh, N.C.
 Mr. & Mrs. Gary Magnotte, Pompano Beach, Fla.
 Mrs. Terese Marsh, Ft. Lauderdale, Fla.
 Don Maurer, Lewes, Del.
 Dr. Arthur Merrill, Easton, Md.
 R. W. Menzel, Tallahassee, Fla.
 Mr. & Mrs. Donald Moore and family (1)
 Mr. & Mrs. Joseph Morrison, Washington, D. C.
 Mr. & Mrs. Francis Murray, Lighthouse Point, Fla.
 Dr. Harold Murray, San Antonio, Tex.
 Miss Hellen Notter, Jacksonville, Fla.
 Dr. & Mrs. J. J. Parodiz, Pittsburgh, Pa.
 Mr. & Mrs. Richard Petit and Betsy,
 North Myrtle Beach, S. C.
 Mr. & Mrs. Fred Pfaff, Chicago, Ill.
 Cynthia Plockelman, West Palm Beach, Fla.
 Hugh Porter, Morehead City, N. C.
 W. Lloyd Pratt, Jr., Fort Worth, Tex.
 Mrs. Dorothy Raeihle, Elmhurst, N. Y.
 Dr. & Mrs. Harold Rehder, Washington, D. C.
 Howard Root, West Palm Beach, Fla.
 John Root, West Palm Beach, Fla.
 William Ross, West Palm Beach, Fla.
 Dr. Henry Russell, Cambridge, Mass.
 Mrs. Frieda Schilling, St. Louis, Mo.
 Mr. J. Gunn Seville, Dunedin, Fla.
 Miss Violet Seville, Dunedin, Fla.
 William Shaw, Easton, Md.
 Dr. & Mrs. Francis A. Smith, St. Petersburg, Fla.
 Dr. & Mrs. David Stansbery and family (2),
 Columbus, Ohio
 Mr. & Mrs. Dan Steger, Tampa, Fla.
 Carol Stein, Columbus, Ohio
 Mrs. Leo Tate, Lake Jackson, Tex.
 Mrs. Myra Taylor, San Antonio, Tex.
 Mr. & Mrs. Albert Taxson, Bronx, N. Y.
 Mrs. Fran H. Thorpe, Miami, Fla.
 Mrs. Patricia Torrance, St. Petersburg, Fla.
 Dr. Ruth Turner, Cambridge, Mass.
 Gordon Nowell-Usticke, St. Croix, Virgin Islands
 Mrs. J. Andrews Wasson, Corpus Christi, Tex.
 Milton Werner, Brooklyn, N. Y.
 Mrs. J. Smith Whiteside, Indian Harbour Beach,
 Fla.

NOTE: In addition to those registered, a number of members of the Astronaut Trail Shell Club were in attendance, staffing the registration desk.
 125 people registered, including 6 children.



THE AMERICAN MALACOLOGICAL UNION, INC.
THIRTY-SEVENTH ANNUAL MEETING
COCOA BEACH, FLORIDA
JULY 15-19, 1971



Group photograph:

1. Mrs. Esther Parodiz, 2. Dr. Juan J. Parodiz, 3. Dr. William Clench, 4. Mrs. Lois Rehder, 5. Dr. Harald Rehder, 6. Mrs. Bernadine Baker, 7. Dr. David Stansbery, 8. Mrs. Mary Lois Stansbery, 9. Mrs. Marian Hubbard, 10. M. Karl Jacobson, 11. Mrs. L. Jacobson (Pinky), 12. Mrs. Louise Clarke, 13. Jerome Bijur, 14. Mrs. Lucia King, 15. Mrs. Wilma Baker, 16. Kirk Anders, 17. Mrs. Morley Bishop, 18. Mrs. Fran Thorpe, 19. Mrs. Kleinie Fieberg, 20. Mrs. Kathryn Pfaff, 21. Albert Lindar, 22. Mrs. Charlotte Lindar, 23. Dr. Arthur Clarke, 24. Carol Stein, 25. Dan Steger, 26. Mrs. Mary Long, 27. Dr. Henry Russell, 28. Mrs. Dorothy Beetle, 29. Mildred Smith, 30. Fred Pfaff, 31. Mrs. Cornelia McInnes, 32. Mrs. Nell Lowry, 33. Walter Lowry, 34. Arthur Merrill, 35. Mrs. Anne Taxson, 36. Mrs. Dorothy Morrison, 37. Mrs. J. Ferguson, 38. Dr. John Ferguson, 39. Mrs. Beth Johnson, 40. Mrs. Jeanne Whiteside, 41. Mrs. Connie Boone, 42. Dr. Dee Dundee, 43. Mrs. Mildred Tate, 44. Mrs. K. R. Lewis, 45. Mrs. Emily Smith, 46. Dr. Francis A. Smith, 47. Hugh Porter, 48. Bill Ross, 49. Mae Ross, 50. Francis Murray, 51. Louise Murray, 52. Howard Blum, 53. Mildred Blum, 54. Violet Seville, 55. J. Gunn Seville, 56. Albert

Taxson, 57. Dr. Joseph Morrison, 58. Judge Benjamin Lencher, 59. Mrs. Benjamin Lencher, 60. Lt. Col. Corinne Edwards, 61. Howard Root, 62. Gary Magnotte, 63. Mrs. Rudi Magnotte, 64. Dr. Carl Gugler, 65. Ken Bazata, 66. Michael Castagna, 67. William Shaw, 68. Mrs. Jane Brooks, 69. Cynthia Plockelman, 70. Mrs. Mary Ford, 71. J. Flynn Ford, 72. John Root, 73. W. Lloyd Pratt, Jr., 74. Mrs. Dorothy Raeihle, 75. Mrs. Ruth Hunkins, 76. Mrs. Audrey Holiman, 77. Wayne Holiman, 78. Mrs. Myra Taylor, 79. Dr. Donald Moore, 80. Mrs. Cindy Moore, holding Walter Moore, 81. William Lyons, 82. Mrs. Betsy Petit, 83. Gordon Nowell-Usticke, 84. Mrs. Juliette Compitello, 85. Mart Hulswit, 86. Mrs. Maria Hulswit, 87. Dr. Edward LaRoe, 88. Milton Werner, 89. Hellen Notter, 90. Dr. Lake Fowler, 91. Mrs. Lake Fowler, 92. Dr. Marc Imlay, 93. Jack Costello, 94. T. J. Costello, 95. Mrs. Florence Kuczynski, 96. Mrs. Sophie Kuczynski, 97. Mrs. Susan Gallagher, 98. Linda Stansbery, 99. Mrs. Miriam Hicks, 100. Richard Petit, 101. Dr. Harold Murray, 102. Mrs. J. Andrews Wasson, 103. Edwin Hicks, 104. Mrs. Patricia Torrance, 105. Mrs. Vera Roberts, 106. Millie O'Mara, 107. Mrs. Eleanor Hillman, 108. John Baker.

THE AMERICAN MALACOLOGICAL UNION, INC.

ACTIVE MEMBERS

Membership List Revised October 20, 1971

- Abbott, Dr. and Mrs. R. Tucker, Delaware Museum of Natural History, Greenville, Del. 19307
Academy of Natural Sciences Library, 19th and the Parkway, Philadelphia, Pa. 19103
Adams, Lawson, 584 Banyan Blvd., Naples, Fla. 33940
Aguayo, Dr. Carlos G., College of Agriculture, Mayaguez, Puerto Rico 00709
Albert, Mrs. Ernest, 905 Bayshore Blvd., Safety Harbor, Fla. 33572
Aldrich, Dr. Frederick A., Marine Sciences Research Lab., Memorial Univ., St. Johns, Newfoundland, Canada (Decapod cephalopods)
Alexander, Robert C., 423 Warwick Road, Wynnewood, Pa. 19096
Allen, Dr. J. Frances, 6000 42nd Ave., No. 311, Hyattsville, Md. 20781
Allen, James E., 1108 Southampton Dr., Alexandria, La. 71301 (Tertiary micro-mollusca)
Allen, Mrs. Lawrence K., Box 822, Port Isabel, Texas 78578 (*Murex*, *Pecten*, world marines; dealer)
Allen, Miss Letha S., 187 Argyle St., Yarmouth, Nova Scotia, Canada (General)
Anders, Kirk W., Shells of the Seas, Inc., P. O. Box 1418, Ft. Lauderdale, Fla. 33302 (Volutidae; all rare shells)
Anderson, Carleton J., Kettle Creek Road, Weston, Conn. 06880
Andrews, Mrs. Jean (Wasson), 241 Melrose, Corpus Christi, Tex. 78404
Angstadt, Mrs. Earle K., Longview Farm, 959 Whitner Rd., Reading, Pa. 19605
Arnold, Ben E., Rt. 5, Box 27, Port Orchard, Wash. 98366
Aslakson, Capt. and Mrs. Carl I., 5707 Wilson Lane, Bethesda, Md. 20034
Athearn, Herbert D., Rt. 5, Box 376, Cleveland, Tenn. 37311 (Freshwater)
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- Carr, Mrs. Jack C., 912 Broadway, Normal, Ill. 61761 (Exchange worldwide marine)
- Castagna, Michael, Va. Inst. Marine Sci., Wachapreague, Va. 23480 (Pelecypod larval behavior)
- Cate, Mr. and Mrs. Crawford N., 12719 San Vicente Blvd., Los Angeles, Cal. 90049 (Winter: P. O. Drawer R, Sanibel, Fla. 33957. (*Mitra*, *Cypraea*; no exchanges)
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- DuBar, Dr. and Mrs. Jules R., Geoscience Dept., Morehead State Univ., Morehead Ky. 40351 (Cenozoic and recent mollusks — ecology and paleoecology)
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- Gilmour, Thos. H. J., Dept. Biology, U. of Saskatchewan, Saskatoon, Saskatchewan, Canada (Anisomyarian bivalves)
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BULLETIN for 1972



AMU, Thirty-Eighth Annual Meeting

THE AMERICAN MALACOLOGICAL UNION, INC.

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Published
March 23, 1973

THE AMERICAN MALACOLOGICAL UNION, Inc.



BULLETIN

for 1972



AMU, Thirty-Eighth Annual Meeting

THE AMERICAN MALACOLOGICAL UNION, INC. THIRTY-EIGHTH ANNUAL MEETING

Galveston, Texas

July 9-14, 1972

The 38th Annual Meeting started off very socially on Sunday, July 9th. After registering, the members assembled at 5 o'clock in President Merrill's suite for his "hospitality hour". Hors d'oeuvres, supplied by our Texas hosts, included luscious melon as well as traditional nibbles. It was a time for renewing acquaintances and making new ones. We had several members from California, and one from as far away as Calgary, Canada. There were plenty of suggestions regarding good places to eat, and plenty of offers of transportation and company for dinner. The spacious lobby of the Galvez Hotel permitted conversations to be continued into the night.

Registration was resumed on Monday morning, and our thoughtful committee made sure there was someone at the desk all through the meeting to take care of our questions and problems. The Annual Meeting was called to order at 9:30 a.m., and papers started promptly at 10:00. Those who were used to having the papers start in the afternoon were surprised, and some who arrived at the hotel late in the morning were disappointed at having missed part of the program. Let that be a warning to you!

At 5 p.m. we started boarding buses and headed for supper at Jamaica Beach, which is west of Galveston. Dinner was not actually on the beach but in an open-air pavilion, one flight up. The tables were decorated with molluscan goodies, a packet of local or exotic shells at each place. The food was delicious, a fried fish dinner served buffet style. It was nearly sunset when the buses started back toward the hotel. One bus took some of us to the wide, sandy Gulf beach before returning to the Galvez. Although the tide was going out, the pickings were poor. However, for most of us it was a new area and new shells, and we did get a few live *Donax* and sand dollars. We were eventually coaxed back to the bus and returned to the hotel. It was then full low tide, so some continued the search with flashlights on the beach in front of the Galvez Hotel. We found several species alive on pilings, as well as young *Oliva sayana* making tracks in the wet sand. The rock jetties held surprisingly few mollusks, but someone interested in crabs and other crustaceans would have been delighted.

Tuesday was a full day of papers, with a break at noontime for the group photograph. Of the 127 people registered, less than 100 appeared to have their picture taken. I am sure that more would have ventured out of the air-conditioned comfort of the

hotel if they had known how quick and painless it would be. You can see the fine results of the photographer's work in the Bulletin. In addition to registrants, there were a number of children and spouses at the Galvez. The children and grandchildren got acquainted with each other immediately; see the first row of the group photograph.

The evening program was scheduled as an informal gathering, but it was especially interesting. We heard Twila Bratcher tell about the Ameripagos Expedition, of which she was a member, and she showed her slides. We also saw Parts 1, 3 and 4 of *Intertidal Life of the North American West Coast*. Part 2 on *Mollusca* was shown last year in Cocoa Beach. The movies were produced for the National Museums of Canada by the National Film Board of Canada and are available on loan from the National Museums of Canada in Ottawa.

Wednesday morning was a symposium on genetics, cytogenetics and hybridization of marine mollusks. The afternoon consisted mostly of meetings. After lunch, President Merrill met with his committee chairmen, and the various committees met separately to discuss and decide on various problems. Please note here that the Conservation Committee is an open committee, and *all* members are invited to attend meetings and contribute to the discussions. The full Executive Council met at 3:30 p.m. A summary of their actions is given in the report of the Annual Business Meeting in this Bulletin. The relatively few members who were not on any committee had time to go sightseeing or shopping.

The informal gathering that evening was Shell Club Night, and as usual there was not enough time to do or say all the things we wanted to do and say. Bessie Goethel was mistress of ceremonies.

Thursday morning saw the last of the papers presented. Lunch was an extra special treat. In the lobby was a sign inviting all AMU members to a "shrimp and crab boil" aboard the *Captain McGinn* as guests of Mr. and Mrs. Thomas McGinn, who were attending their first Annual Meeting. Tom operates his own shrimp boat out of Cut Off, Louisiana, and he had been fishing Thursday morning. AMU members responded to his invitation with enthusiasm, and consumed an extraordinary amount of seafood. We extend an extra-special "thank you" to the McGinns for the delicious seafood.

The Annual Business Meeting was the only busi-

ness Thursday afternoon. Adjournment by 3:30 p.m. gave the members plenty of time to get into their finery for the Annual Banquet. As on previous evenings, there were many presents and shells at the banquet. At each place was a large freshwater mussel from Lake LBJ, Texas, acquired when the lake was drained. There were many door prizes, including books. The table centerpieces were flower-like creations of driftwood, shells, and other marine life. We thank Mrs. Phyllis Dale for contributing these beautiful centerpieces. Ten percent of us went home with one of them - those with the proper stickers under their chairs. The after-dinner address by Dr. Carol Lalli of McGill University was about gymnosomatous pteropods. She made these tiny and little-known mollusks as interesting to us as they are to her, through her excellent talk illustrated with slides.

Friday was the day for field trips. We were offered a choice of three: full-day or part-day marine, or land and freshwater collecting. I went on the full-day marine trip. We collected at seven localities between San Luis Pass and McFadden Beach, 10 miles west of the Sabine River, before returning to the Galvez. Dr. Pulley spent some time explaining the geological history of the area while we were munching doughnuts on the bus. This explained the semi-fossil *Rangia* shells we found at several spots. Mildred Tate handed each of us a pair of *Chione clenchi* Pulley together with an article pointing out how it differs from *C. latilirata* and *C. paphia*. We had lunch at McFadden Beach. Dr. Pulley put on a big leather apron and became the chief cook, grilling frankfurters for us and telling the uninitiated how to create chili dogs. There was plenty to drink, and several cold watermelons to carve up and eat in the shade of the bus. This "poor" collecting day by Texas standards provided me with at least 50 species, seven of them live. At Rollover Pass we had the thrill of finding so many live *Thais haemastoma* that you could pick the few with the colouring you wanted and put back the other dozen

or more. One stop at the Galveston East Beach Lagoon provided the first live *Cerithidea pliculosa* and *Melampus bidentatus* that some of us had ever seen. Dr. Pulley told us to look for *Melampus* under debris well back from the water's edge. This was the first time I ever thought kindly about litterbugs, for there was at least one *Melampus* under each beer can that I turned over. On the ride back to the hotel we compared notes about our finds and swapped or gave away extras of special goodies, like *Epitonium* or molluscan egg cases. We trailed into the back door of the Galvez with buckets and plastic bags full.

We had showered, dined and started cleaning shells before the last of the freshwater collectors arrived, about 8 p.m. The highlight of their day - and probably the highlight of the year - was their trip to Barker Dam. In planning the trip, the local people hoped to have the water level of the lake lowered for collecting. When Mrs. Connie Boone and Harold Murray approached the local official to actually close the dam, he had to call the head engineer in Galveston for permission. After some 15 minutes' delay, permission was granted for a one-hour closing of the gates. The gates were closed at 3 p.m., and by 3:15 the 3-4 feet of water had dropped to a few inches. Freshwater mollusks were collected with ease while the dam officials watched in amazement. At 4:00 the gates were reopened and all left happy and in total disbelief at what they had accomplished. Not only had they increased the collections of several museums but they were probably the first malacologists to have a dam closed especially for their benefit. A special tip of the hat to the Corps of Engineers!

Leaving is always a little sad, but we had to chuckle as we checked out of the Galvez on Saturday morning. A "yellow rose of Texas" from the President's Hospitality Hour was still standing in a glass full of water on the hotel's front desk!

Marian S. Hubbard
Recording Secretary

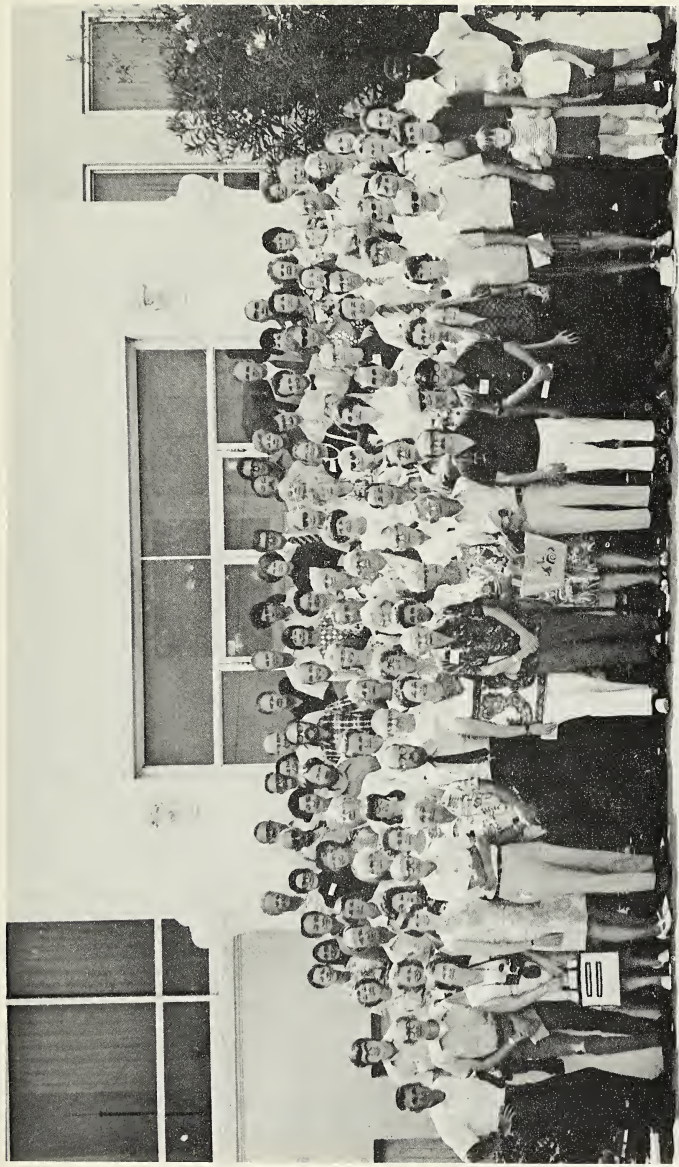
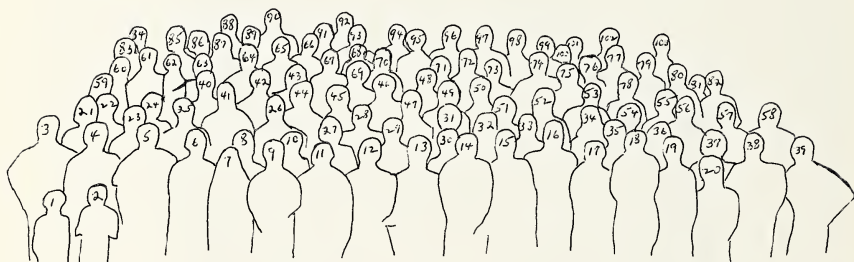


PLATE 1. Group photograph, American Malacological Union, Inc. thirty-eighth annual meeting, 1972.

THE AMERICAN MALACOLOGICAL UNION, INC.
THIRTY-EIGHTH ANNUAL MEETING
GALVESTON, TEXAS
JULY 9 - 14, 1972



Group photograph identification:

1. Eric Long, 2. Jeremy Long, 3. Frank Ukoli, 4. Glenn Long, 5. John B. Burch, 6. Doug Smith, 7. Priscilla Merrill, 8. Lucille Taylor, 9. George A. Te, 10. Cleta Mahavier, 11. Philip T. LoVerde, 12. Henry D. Russell, 13. Margaret Teskey, 14. William Clench, 15. Ann Young, 16. Arthur Merrill, 17. M. Karl Jacobson, 18. Paul Jennewein, 19. Marian Hubbard, 20. Florence Kuczynski, 21. Leona Grantier, 22. Jeanne Whiteside, 23. Kirk Anders, 24. Adelaide Johnstone, 25. Kenneth Boss, 26. Gale Sphon, 27. Betty Allen, 28. Shi-Kuei Wu, 29. Al Lindar, 30. Charlotte Lindar, 31. Kathryn Pfaff, 32. Corinne Edwards, 33. Daniel Steger, 34. Annie Schmidt, 35. Dorothea Franzen, 36. Constance Boone, 37. Katy Fowler, 38. Harold D. Murray, 39. Robert Lipe, 40. Artie L. Metcalf, 41. George M. Davis, 42. Charles S. Richards, 43. Benjamin Lencher, 44. Margo Musselwhite, 45. Jennie Lencher, 46. Laura Bauer, 47. Fred Pfaff, 48. Harvey Meyer, 49. Albert Taxson, 50. Eleanor Mead, 51. Anne Taxson, 52. Hugh J. Porter, 53. H. Wayne Holliman, 54. Irene H. Porter, 55. Jeneva Porter, 56. Carl Gugler, 57. Twila Bratcher, 58. Ken Bazata, 59. Carol Lalli, 60. Louis Goethel, 61. Donald Moore, 62. Walter Moore, 63. Cindy Moore, 64. Helen Ness, 65. David Stansbery, 66. Sarah Swartz, 67. Unice Nace, 68. Hellen Notter, 69. Mary E. Long, 70. Maude Meyer, 71. Carol Stein, 72. Betty Sue Miller, 73. Al Mead, 74. Arthur Clarke, 75. W. Lloyd Pratt, 76. Alice Burke, 77. Sam Miron, 78. Audrey Holliman, 79. Laura S. Barnes, 80. Ford Bratcher, 81. Jennifer Merrill, 82. Lilburn Hettick, 83. Bessie Goethel, 84. Bobby Steger, 85. Frieda Schilling, 86. Dorothy Morrison, 87. Hessie Kemper, 88. Joseph P. E. Morrison, 89. Anne Speers, 90. William Bledsoe, 91. Mildred Tate, 92. Wes Tunnell, 93. Paul McGee, 94. Larry Petersen, 95. Wilma Baker, 96. Marc Imlay, 97. Walter B. Miller, 98. Hollis Q. Boone, 99. John A. Baker, 100. Fannie Miron, 101. Harold Harry, 102. Alan Solem, 103. John Root.

Other members and guests who attended the meeting are: Hugo Bauer, Louise Beeman, Grace Broussard, Sybil Burger, Nadalyn Cotten, John D. Davis, Dolores S. Dundee, Lake Fowler, Barkley Glass, Mrs. Barkley Glass, Jewell Griffin, Mary J. Griffin, Mrs. Harold Harry, Virginia Joiner, Virginia Lee, Mrs. Paul McGee, Thomas McGinn, Madeline Merren, Esse Merrill, Charlotte Patterson, Helmer Odé, Mary Pinkerton, Thomas E. Pulley, Helen Quentin, Sammy Ray, Selma Snider, Barbara Solem, Linda Stephens, Myra Taylor, William J. Wardle, Beuleah White, Zoula Zein-Eldin.

PAPERS AND ABSTRACTS OF PAPERS
READ AT AMU 38TH ANNUAL MEETING

MOLLUSKS FROM A SMALL LANDLOCKED MEXICAN LAGOON^{1,2}

Donald R. Moore *

Cozumel is an island at the extreme northwestern end of the Caribbean Sea. It lies 16 km off the eastern coast of Quintana Roo, Yucatan, and 240 km due southwest of Cabo San Antonio, Cuba. The island is on the edge of the Yucatan Channel which funnels Caribbean water into the Gulf of Mexico and the Straits of Florida. The island does not lie on the shallow shelf as one would expect from its proximity to Yucatan, but rises abruptly from depths of more than 300 m. The slope is also steep on the opposite Yucatan coast hence there is a deep channel between island and mainland. The Yucatan Current flows on both sides of the island, and reef corals grow right to shore on hard bottom.

The island is low, flat, and is composed of oolitic limestone. Some evidence of solution and collapse can be seen on the western side at Caleta Bay and at Chancanab Lagoon. This lagoon is very small, about 150 by 200 m, and is completely landlocked. The bottom is flat, and is about two m deep. The water is quite saline, and several species of corals live there. Water exchange with the open sea is maintained by an underground passage. This underground passage is the type locality for *Dimyella starcki* Moore, a small (3 mm) oyster-like bivalve that Walter Starck collected in 1961 (Moore, 1970).

There is a deep crevice around the edge where the bottom meets the vertical side of the lagoon. This shows that Chancanab Lagoon was once a cavern. The roof collapsed and now the former upper surface forms the floor of the lagoon. This event must have happened in fairly recent times since the space between the lagoon floor edge and the vertical side of the lagoon has not yet filled with debris. The old passageway into the cavern was not completely blocked by the fall, and permits water circulation with the adjacent marine environment. This circulation is sufficient to maintain some small corals

(*Agaricia* and *Porites*) and an interesting population of small mollusks.

Those that could be considered macromollusks were rather small and few in number. I observed *Cerithium litteratum*, and collected, in sediment samples, *Cerithium eburnium*, *Chione cancellata*, a *Tellina*, and *Divaricella quadrisulcata*. I did not see any large species such as *Strombus gigas* or *Fasciolaria tulipa*.

A special effort was made to collect the little oyster-like micromollusk *Dimyella starcki*. Rocks brought up from within the passage entrance were examined later with a hand lens, but without result. Species of the Family Dimyidae appear to be negatively phototropic, and the type specimens of *D. starcki* were no exception. They were found on the base of a colonial coral collected from deep within the passage. However, when a sediment sample from near the middle of the lagoon was sorted, twenty upper valves of *D. starcki* were found. Since the water in the lagoon is very still, the dimyids must have been living attached to rocks very close to where the sample was collected. Thus *D. starcki* is unique among the Dimyidae since it is the only known species that will live in very shallow water where sunlight is strong.

Altogether, 40 species of micromollusks and young specimens of eight species of macromollusks were picked out of the sediment sample. Those identified were as follows:
Gastropods

- Tricolia bella* Smith, 1937
- Pachystremiscus pulchellus* (Olsson & McGinty, 1958)
- Pachystremiscus ornatus* (Olsson & McGinty, 1958)
- Alvania auferiana* (Orbigny, 1842)
- Amphithalamus vallei* Aguayo & Jaume, 1947
- Rissoina multicostata* (C. B. Adams, 1850)
- Rissoina bryerea* (Montagu, 1803)
- Zebina browniana* (Orbigny, 1842)
- Cochliolepis holmesi* (Dall, 1889)
- Caecum imbricatum* Carpenter, 1858
- Caecum plicatum* Carpenter, 1858
- Meioceras nitidum* (Stimpson, 1851)
- Meioceras cornucopiae* Carpenter, 1858
- Rissoella galba* Robertson, 1961
- Cerithium eburneum* Bruguière, 1792

¹ Acknowledgement is made to the donors of the Petroleum Research Fund, administered by the American Chemical Society, for partial support of this research.

² Contribution No. 1596 from the University of Miami, Rosenstiel School of Marine and Atmospheric Science.

*Institute of Marine Sciences, Miami, Fla. 33149

Cerithium litteratum (Born, 1778)
Cypraeolina ovuliformis (Orbigny, 1842)
Odostomia laevigata (Orbigny, 1842)
Retusa candei (Orbigny, 1841)

Bivalvia

Dimyella starcki Moore, 1970
Divaricella quadrisulcata (Orbigny, 1842)
Americardia guppyi (Thiele, 1910)
Condylocardia smithi (Dall, 1896)
Saxicavella sagrinata Dall & Simpson, 1901
Chione cancellata (Linnaeus, 1767)

In the unidentified material, two species of Nuculidae were of great interest. The larger, with a maximum size of less than two mm., is found over a wide area throughout the Caribbean. Although I had collected a number of specimens elsewhere, Chan-

canab Lagoon sediments were unusually rich in this species, some 90 specimens in all.

The other nuculid is considerably smaller, and is mature at about 500 μ . The largest specimen measured 520 μ . It might be considered rash to call this microscopic clam an adult, yet another species, only slightly larger (600 μ), has been found off the Atlantic Coast of Nicaragua. The two species are clearly congeneric, and both give every indication of maturity at a very small size. The two species are evidently the smallest bivalve species yet found.

LITERATURE CITED

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THE CASE FOR A DRIFTLESS NATIONAL PARK

Marc J. Imlay *

In the Driftless Area of southeastern Minnesota, southwestern Wisconsin, northeastern Iowa and northwestern Illinois at least four likely endangered species of clams and snails still survive.

This is the famous Northern Area, about 150 miles in diameter, that the four recent ice ages did not significantly demolish with their great glacial drifts. Other than by visiting this spectacular northern area one must travel several hundred miles south to find areas with ancient dendritic patterned drainages, low mosquito counts, and tall conical outliers of deep valleys.

Cumberlandia monodonta, an endangered fresh-water mussel according to Stansbery (1971), commonly known as the Spectacle-Case, is the only species in an old genus. It appears to have more protein than other mussels in its shell composition and in fact all the museum specimens I have seen have developed cracks even though they were collected whole in the water.

Its ability to live in a very particular microhabitat (firm mud and quiet water because of its aforementioned fragile condition but very near rapid water because of high respiratory requirements) (Stansbery, 1967) is possibly why this anomaly is still with us today. *Cumberlandia monodonta* was found in the Driftless Area (Baker, 1928) at Prairie du Chien but otherwise is only found hundreds of miles further south. The Army Corps of Engineers, fortunately for this species, has decided to relocate 157 old buildings for flood control as an alternative to building a dam on the Mississippi River at Prairie du Chien.

Hendersonia occulta, according to Morrison (1929), a likely endangered flood plain snail in the Driftless Area, is another matter. Found in the Kickapoo Valley, this conspicuous red snail that was the original biological evidence of the Driftless Area, is threatened by a dam that will inundate a full third of the best part of the Kickapoo Valley. Commonly known as the "wild-cherry-stone" snail, the rarity of this helminid operculate was described by Morrison in 1929. It is now considered by Morrison (1972) as a species that may soon become endangered if it is not already. The northern existence of a helminid is something of an anomaly anyway and such southern forms have been decreasing in northern areas.

On July 2, 1972, Dan Engstrom and I found *Hen-*

dersonia occulta in the upper reaches of the specific area to be inundated by the dam. This species was abundant on a slope under leaves in a dark sombre cave-like waterfall area known as Ice Cave located in the lower part of Wild Cat Mountain State Park. Low shrubbery on nonsandy soil was evidently also necessary.

Dan and I also found *Hendersonia occulta* that day at the east side of Devils Lake, Wisconsin, on a slope at the base of a talus fall, thus confirming an earlier find there by Morrison (personal communication). Situated at the edge of the Driftless Area, the spectacular valley of Devils Lake is a nonglaciatic remnant of the old bed of the Wisconsin River.

Found relatively near the water on woody, leafy ground, the snail was shielded from sunlight by the very large rocks of the talus slope. Again, low shrubbery on nonsandy soil was evidently also necessary.

Devils Lake is located at Devils Lake State Park, an intensive use recreation area.

Zonitoides limulatus was found by Dan Engstrom, John Satterlee, and myself in an area to be inundated by the Kickapoo Dam. Morrison considers this snail (personal communication) probably endangered and certainly a candidate for the watch list of species that may become endangered.

The known range of *Discus macclintocki* on the Earth "is an area about ten feet long and a foot wide at the mouth of a cave in Bixby State Park, Clayton County, Iowa" in the Driftless Area (Hubricht, 1972).

The Duluth, Minnesota Chapter of the Izaak Walton League of America has prepared a resolution (Eaton, 1972) which includes a statement that "the present program of producing wetlands with a few exceptions is more environmentally sound by the plugging of ditches for areas that were once wetlands than by the impoundment of creeks in areas that are naturally dry." It was pointed out as an example that if ever *Discus macclintocki* were thus flooded, it might be eliminated from the Earth. Just such a disaster has been uncovered recently by the Sierra Club in California (Roth, 1972) where the habitat of an endangered snail is threatened by "the management of marshland for the benefit of waterfowl."

There are undoubtedly many other relict species in the Driftless Area. Some of these are probably of strictly northern character and mostly as yet new (undescribed) species which will spread to the rest of the North during this present interglacial period of which only about 10,000 years have passed. The

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Driftless Area is a priceless preview of the future. This is what a far vaster area is predicted to be like prior to the next glacial period. The Driftless Area must be protected not only for its beauty (it is close in proximity, as a primitive undeveloped area, to major population centers), but also as the single "seed" area for the post glacial redistribution of these species. There is, in summary, a strong case for a Driftless national, state and/or local park system which would include portions of Minnesota, Wisconsin, Iowa and Illinois.

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SHELL TRUMPETS AND CONCENTRIC CIRCLES IN PRE-COLUMBIAN TOMB OFFERINGS

Glenn A. Long *

ABSTRACT

To find the practical use of shell trumpets in a framework of ritual operation is the ultimate goal of this study. Specifically, the purpose of the paper in hand is to make the subject accessible to the membership. There is a second objective. A regular association of shell trumpets and incised concentric circles is one category of recurrent elements and this association is set apart for discussion in depth, herein.

*Among cultural objects in use in the Americas before the Spanish Conquest were specimens of *Strombus gigas* Linné, *Pleuroploca gigantea* (Keiner), and *Turbinella angulata* (Solander). Their use was basically ritualistic. They were part of the shaman's equipment to call into operation the spirits, perhaps to awaken beneficent deities and ward off affects of those which were evil. Often these shells were found in tombs, as were ceramic replicas, accompanying human remains. In certain instances the shells were decorated with incised patterns of concentric circles.*

A mystery yet unsolved is the regular coincidence of shell trumpets and concentric circle motifs in affiliation with aspects of death and phenomena of earthly and subterranean significance. We present data illustrative of this functional and motivic coincidence and speculate toward a reasonable interpretation of their association.

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21218



PLATE 2. Conch Shell Trumpet, *Pleuroploca gigantea* (?)
Nayarit, Mexico
Proctor Stafford Collection
Photo, courtesy of the Los Angeles County Museum

VARIATIONS IN *TRIODOPSIS MULTILINEATA* IN NEBRASKA

Carl W. Gugler *

ABSTRACT

Unbanded and banded Triodopsis from Nebraska traditionally have been assigned to T. albolabris and T. multilineata, respectively. On the basis of geographical distribution, the unbanded Triodopsis would, of necessity, be assigned to T. a. allenii.

Biometric analyses and breeding experiments indicate that Nebraska Triodopsis should be assigned to T. multilineata, with a smoothly continuous variation from the red, undescribed variety rubra to the unbanded, undescribed variety alba.

Morphological investigations of unbanded Triodopsis populations from the Lexington, Missouri area reveal a conspicuous difference in the talon. The Missouri specimens have the talon enveloped by a relatively thick, fatty sheath. Such a sheath is not conspicuous in Nebraska specimens, either banded or unbanded.

This finding lends support to the interpretation of the Nebraska populations as variants of the species multilineata. Further studies of morphology and of the results of interbreeding are indicated, but the provisional conclusion is that the Missouri unbanded Triodopsis represent the true T. a. allenii, while the Nebraska populations represent highly variable T. multilineata.

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THE TALON OF SOME NEBRASKA SUCCINEIDS

Ken Bazata *

ABSTRACT

The morphology of the talon in two common Nebraska succineids was discussed.

Succinea ovalis has a talon with three chambers, viz., a basal, compact, egg chamber and two elongate distal chambers for sperm storage. One of the sperm chambers is longer than the other; its distal end is recurved over the end of the shorter chamber.

Seasonal variation in morphology of the talon was described.

The talon of S. pseudavara also has three chambers, but the sperm chambers are of equal length, and the talon as a whole is relatively shorter. The sperm chambers are more widely separated from each other than is the case in S. ovalis.

Pigmentation patterns in all components of the reproductive tract in both species are highly variable.

On the basis of this study, with particular emphasis on variability within single populations, it seems premature to make firm statements of taxonomic and phylogenetic implications.

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ANCYLODORIS, ITS WELL-DESERVED OBLIVION (MOLLUSCA, NUDIBRANCHIA)

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The faunas of the ancient fresh-water lakes command attention because of their unusual diversity and singular endemicity. The study of the mollusks of Lake Tanganyika in Africa, Ohrid in Yugoslavia, Titicaca in South America, and Baikal in Siberia is scarcely over a hundred years old. Numerous malacologists described - sometimes greatly overnamed - the unusual mollusks of these isolated basins. Theories were elaborated to account for their zoogeographic peculiarities. The idea of Reliktensee proposed that the present inhabitants of the lakes were veritable antediluvian remnants or survivors of a far distant past and far different faunas. Certain adherents of this notion could not forbear the attractive, if not daring, idea that the lakes were in reality ancient inland seas, turned to fresh-water lakes. Indeed, some faunal elements, for example, the seal in Lake Baikal, are of marine origin but others were all too often figments of the author's imagination. One such case is the alleged fresh-water opisthobranch of Lake Baikal. Now of purely historical interest, it at one time was considered additional proof of the marine origin of the molluscan fauna of Lake Baikal and occasioned a feud between the doyen of Russian malacologists, Lindholm, and the celebrated brothers, Wladyslaw and Benedikt Dybowski.

Ancylodoris baicalensis was described by W. Dybowski in 1900. As if to counter possible criticism, he attempted to justify the peculiar circumstances by which the collection came into his hands and to explain the lack of any real locality data. Five specimens then preserved at the Museum in Lemberg in Galicia (now L'vov in the Ukraine) constitute the type-series of *A. baicalensis*. No label certified the provenance of these specimens and no record of them is given in a recent appraisal of the Dybowski collection (Zdun, 1969).

The importance of *Ancylodoris* as W. Dybowski (1900) explained it, was that this was strong proof of the marine origin of the Baikalian fauna. At that time fresh-water opisthobranchs were thought to be unknown.¹

Benedikt Dybowski thundered his support not only of this hypothesis but also of the provenance of the specimens of *Ancylodoris*, stating that they came from considerable depths in the lake, as indicated by

their white color (Dybowski, 1900: 489). Lindholm (1927) dryly added that two decades in alcohol might have some effect on body color! B. Dybowski further elaborated his strange ideas about the fauna of Baikal (Dybowski and Grochmalicki, 1920), and he was one of the few modern zoologists to find one of his works on the Official Index of Rejected and Invalid Works in Zoological Nomenclature.

According to B. Dybowski (1911) the specimens of *Ancylodoris* were obtained from Lake Baikal along with several planarians which Grube described. As Lindholm (1927) has summarized, the specimens were shipped to W. Dybowski in Dorpat (Tartu), Estonia during the 1870's, then to Breslau, Germany to Grube, then to Wrzesniewski in Warsaw, then to Lemberg and finally to Niankow (in Minsk Province, Russia) where W. Dybowski, retired and in poor health (Hryniewiecki, 1910), rediscovered them and described *Ancylodoris*. Lindholm (1927) tartly observed that it might have been possible - over all those travels in nearly 25 years - that some mix-up had occurred.

Other evidence leads one to question the authenticity of these specimens. For example, Grube was an authority on the Turbellaria and he published an extensive monograph on the Baikalian forms. Grube was a staunch proponent of the marine origin of that fauna, and, as Lindholm (1927) commented, it is virtually inconceivable that he would have overlooked this potentially startling discovery.

The original description (Dybowski, 1900) is reasonably complete though it deals principally with external features. That his knowledge of zoology, which had been appreciable during his professorship in Dorpat, had declined through time and illness is reflected both in his invention of the name *Ancylodoris* and in certain textual remarks. He claimed that the species had a two-fold nature, combining features of the Opisthobranchiata and the Prosobranchiata; thus, he brought together the names *Ancylus* and *Doris*. *Ancylus* is of course not a prosobranch at all

¹ Lindholm (1927) summarized the species of opisthobranchs known to have invaded estuarine or nearly fresh-water habitats. Subsequently, true fresh-water forms have been re-discovered which were actually described in the late nineteenth century and overlooked by the Dybowskis (Bayer and Fehlmann, 1960).

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but a pulmonate.¹ He also suggested that the tentacular outgrowths on the mantle of *Ancylodoris* might be retractable like the spines of 'ein Igel', a European hedgehog, the spines of which have never been known to have this ability. Later (1902) he recognized a specific dorid having affinities to *Ancylodoris*.

With all the thorough studies of the molluscan fauna of Lake Baikal (Kozhov, 1936: 1963), neither any opisthobranch nor any specimen resembling *Ancylodoris* has ever been reported (Cockerell, 1927). In spite of zealous searching for this snail, Korotnev (1902), during his great expedition, noted that he could not find it and that it should only doubtfully be attributed to the fauna of Baikal. In his review of Lake Baikal, Johansen (1925) referred to *Ancylodoris* several times, particularly in regard to the ideas concerning the marine origin of the fauna fostered by the Dybowski brothers. However, he too observed that it was never found again, and that if it were, it might be shown to have been introduced. Thus, the doubts raised by Lindholm (1927) are confirmed, and it can be surmised that the name *Ancylodoris* applies to a nudibranch from some other locality.

The probable relationships of *Ancylodoris* were discussed by Lindholm (1927) who credited Odhner (an acknowledged authority on the opisthobranchs) with the opinions given. Dybowski (1902) himself recognized that *Ancylodoris* was very much like an unnamed nudibranch which Middendorff (1847: 184, pl. 10, figs. 19-21) had referred to *Doris* and suggested it was similar to the case of *Lubomirskia*, a Baikalian sponge, which supposedly showed affinities with a marine form from the Bering Sea. He went so far as to aver that only more careful comparison of these species would indicate whether they were the same or closely related but different species. Middendorff's figured specimen was listed as occurring in the Arctic Ocean along the coast of Russian Lapland and in the Novaya Zembla Islands. Unknown to Dybowski, Herzenstein (1885) had already recognized that the species figured by Middendorff was referable to *Doris bilamellata* Linnaeus, a species presently known from this region (Odhner, 1907: 1940).

Ancylodoris has been infrequently cited in the literature and always placed among the dorid nudibranchs. Thiele (1931) questioned the provenance of *Ancylodoris* and regarded its single species as of probable marine origin. He placed the genus in the subfamily Onchidoridinae of the Polyceridae and cited its similarity to *Calycidoris* Abraham (1876). Hoffmann (1933) figured *Ancylodoris*, also noted its similarity to *Calycidoris* and placed it in the Onchidoridinae. Boettger (1954) did likewise. Curiously, in the more recent, extensive taxonomic reviews of

nudibranchs, neither Pruvot-Fol (1954) nor Odhner ([in] Franc, 1968) mention *Ancylodoris*.

Ancylodoris belongs in the family Lamellidorididae, a name now used in preference to the old Onchidorididae for nomenclatorial reasons (Pruvot-Fol, 1954). Probably both *Ancylodoris* and *Calycidoris* should be placed in the synonymy of *Lamellidoris*. The type-species of these nominal genera have been either synonymized or are closely related to one another. *Ancylodoris*, with its type-species by monotypy, *A. baicalensis*, has been made virtually synonymous with *Doris bilamellata* Linnaeus (Dybowski, 1902) and that is the type-species of *Lamellidoris* Alder and Hancock 1855 by monotypy (Russell, 1971). *Calycidoris* has as its type-species, *C. guntheri* Abraham 1876. Russell (1971) noted that no type-locality was given for this species, although for some reason he added that it was found in the Falkland Islands; he is presently unable to confirm this locality (per. Comm.) Without explanation and without mention of *Ancylodoris*, Odhner ([in] Franc, 1968) synonymized *Doris sibirica* Aurivillius 1887 of the Arctic Ocean with *C. guntheri* and since *sibirica* has been placed in *Acanthodoris* (Odhner, 1907), the exact status of *Calycidoris* remains unresolved.

Ancylodoris falls into the synonymy of the well-known *Lamellidoris* and into well deserved oblivion, closing an interesting chapter in the study of the fauna of Lake Baikal.

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¹ Probably misled by Dybowski's mention of *Ancylus*, Berg (1922) remarked that the character of the tentacles and gills in *Ancylodoris* indicated a relationship to fresh-water gastropods.

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ASPECTS OF REPRODUCTIVE BIOLOGY OF *ANGUISPIRA KOCHI*

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ABSTRACT

Preliminary studies of *Anguispira kochi* from central United States and southern Canada have revealed a number of interesting problems.

Anatomically, *A. kochi* is, in general, similar to *A. alternata*, except for the terminal vas deferens. Pilsbry figured a typical muscular epiphallus for *A. kochi*. However, in specimens from Missouri and from Illinois, the terminal vas deferens is complexly sacculated. Histological studies are in progress.

The most perplexing problem encountered in our laboratory arises from the fact that a sample of *A. kochi* sent to us from Lethbridge, Alberta, Canada, produced living young rather than the expected calcareous shelled eggs. Populations from Missouri have been maintained in the laboratory, but have not reproduced. Populations from Illinois have deposited eggs similar to those of *Anguispira alternata*.

Note. During discussions following presentation of this paper the opinion was expressed that the Alberta snails may be *Oreohelix strigosa* (Gould). Ed.

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SYMPATRIC SPECIES OF ELLIPTIO LIVING IN THE ST. JOHNS RIVER, FLORIDA

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Specimens of *Elliptio monroensis* (Lea, 1843), *Elliptio aheneus* (Lea, 1843), and *Elliptio jayensis* (Lea, 1838) were collected living together in the western margin of the St. Johns River, just below the highway 192 bridge, west of Melbourne, Brevard County, Florida, on the occasion of the A. M. U. field trip, July 20, 1971.

Elliptio monroensis (Lea) is the member of the typical *E. crassidens* group endemic in the St. Johns River. To the northward, the larger *E. dariensis* (Lea) is known only from the Altamaha River System. Still further to the north, this typical group is represented by *Elliptio waccamawensis* (Lea), from Lake Waccamaw, North Carolina.

Elliptio aheneus (Lea) is the Florida species of the group until recently called the group of *Elliptio productus* (Conrad). Northward, in the Altamaha River, it is replaced by the most elongate of all *Elliptio*, *E. shepardianus* (Lea). This group of elongated species includes *Elliptio angustatus* (Lea, 1831), which occurs in both South and North Carolina, and northward as far as the Schuylkill River near Philadelphia. The dark species *E. angustatus* is completely biologically separate from the golden, sand-dwelling *Elliptio lanceolatus* (Lea, 1828). The true species *E. lanceolatus* is known only from five river systems in Maryland, Virginia, and North Carolina.

Unio buddianus Lea was also named in 1843 from

the St. Johns River System. However, *Elliptio jayensis* (Lea, 1838) is the earliest name for the extremely common, variable, and widespread peninsular Florida species often called "*buckleyi*". Both Simpson in 1900, and Ortmann in 1912, said that these two named forms so ran together that they were undoubtedly one single species. When we look for relatives, we find that *Elliptio opacatus* (Crosse & Fisher), from Lake Catemaco, southern Vera Cruz, Mexico, is very similar in appearance and reproductive characters to *Elliptio jayensis* (Lea).

On the date of collection, July 20, 1971, one female of each of the three *Elliptio* species in the St. Johns River was partly gravid, with eggs in the lower part of the outer gills. All three were beginning their short (tachytictic) period of reproduction. Therefore they belong to the Family Amblemidae, subfamily Ambleminae, and tribe Pleurobemini, carrying glochidia only in the outer gills. I cannot believe that these three species of the single genus *Elliptio* should be assigned to three separate subfamilies, viz. Pleurobeminae Hannibal, 1912; Elliptioninae Modell, 1942; and Popenaiaadinae Heard & Guckert, 1971.

We are fortunate to have such a clear sympatric record. These three *Elliptio* species have been living together, yet maintaining their separate genetic distinction from the time of Isaac Lea's descriptions almost exactly 130 years ago.

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TAXONOMIC GROUPINGS IN THE LYMNAEIDAE¹

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ABSTRACT

The Lymnaeidae are one of the most common and wide-spread of all animal groups, its species being found in the freshwaters of all the major land masses of the world. Many species and genera have been named, but few malacologists seem to agree on their taxonomy. This is hardly surprising since there is a dearth of critical scientific information available on which to build solid systematic concepts. There is little information on genetics, and almost no data on breeding potential or reproductive isolation for any of the nominal species, and the morphological parameters of no species have been adequately defined in terms of modern biological concepts.

In an effort to gather more systematic data of particular significance for understanding the relationships of the various taxonomic units within the family, we have been using various techniques, ranging from classical conchology to breeding studies. One technique that has been specially illuminating is immunology of lymnaeid foot muscle proteins. Briefly, our procedures included production of antisera in rabbits, and the observation of precipitin reactions between these antisera and antigens of selected lymnaeid species. Of particular pertinence in our immuno-taxonomic study was the preabsorption of antigen from one lymnaeid species and allowing the antibody of another species to diffuse through it in order to meet and react with its own antigen. Thus, in any particular test, we could determine whether or not the species to which we had antiserum contained the same proteins found in the species furnishing the antigen, i.e., whether or not the two species in question had developed immunologically detectable differences in foot muscle proteins during their evolutionary divergence.

Our results showed that, in general, classical taxonomic divisions within the family based on shell characters are more reliable than radular teeth or characters of the reproductive tracts (as previously used), i.e., our immunological studies correlated best with shell characters. *Lymnaea* s.s., *Stagnicola*, *Fossaria* (= *Galba*), *Radix*, *Austropeplea*, *Pseudosuccinea* and *Bulinnea* each forms a distinct immunological group. Finer divisions within these taxa could not be distinguished by our technique.

¹Supported by research grants from the National Institute of Allergy and Infectious Diseases, U. S. Public Health Service (N. I. H. Training Grant No. 5 T1 AI 41), the National Science Foundation (grant GB-7569), and the Foreign Currency Program, Office of International Activities, Smithsonian Institution.

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FOSSIL SNAILS OF THE GENUS *ASHMUNELLA*,
SACRAMENTO MOUNTAINS, NEW MEXICO, AND
REMARKS ON FORMER DISTRIBUTIONS

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ABSTRACT

Four new species of fossils of the land snail genus *Ashmunella* (Pulmonata: Polygyridae) from the Sacramento Mountains, Lincoln and Otero Counties, New Mexico, were discussed. All were judged to be of Pleistocene age. Comparisons were made with living species and some phylogenetic and zoogeographic inferences were made.

At present, in the genus *Ashmunella*, only the variable species *A. rhyssa* (Dall) seems to inhabit the Sacramento Mountains. The known Pleistocene fauna indicates greater diversity of species of the genus in the past. The question was considered whether this diversity was more likely attributable to radiation within a closely allied species group or whether the species were of diverse ancestries within the genus. The latter view was deemed more plausible. One of the species of fossils was suggested as being related to the group of *A. thomsoniana* (Ancey) of northern New Mexico and another to the group of *A. tetrodon* Pilsbry and Ferriss of western New Mexico. Two species were considered as belonging to the group of *A. mearnsi* (Dall) of southern New Mexico and extreme western Texas. The similarity of one of these latter species to *A. ferrissi* Pilsbry of the Chiricahua Mountains, Arizona, was pointed out. The similarity, in this case, was suggested as being most likely a result of convergent evolution in two mountain ranges distant from each other.

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ANATOMICAL STUDIES ON THE SCAPHOPOD, *DENTALIUM TEXASIANUM*
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ABSTRACT

Details of the anatomy of scaphopods, other than shell and radula, have been published on only three species, none of which are present in the New World. Dentalium texasianum Philippi 1848 was collected alive in West Bay of the Galveston Bay Complex in June 1966 and September 1967, but sampling of over 50 stations in that area between January and October 1971 did not yield live specimens. Anatomical studies were made on preserved material of the earlier collections. In most respects the anatomy agrees with the accounts of other species. Two important features have not been previously described. (1) There is a large, tubular cavity in the foot, opening at the base, and lined with epithelium which is continuous with that of the external pedal surface. The cavity extends nearly to the end of the foot. (2) There are two fleshy, semilunar valves extending across the mantle cavity slightly anterior to the mantle collar at the posterior end of the animal. The valves are unequal in size and overlap each other. The larger valve extends from the dorsal wall of the mantle ventrally and covers slightly more than half of the inner diameter of the cavity. The ventral edge of this valve is thicker than the remainder of either valve and may be muscular. The smaller valve extends from the ventral surface of the mantle dorsally and covers the remainder of the opening. It is slightly anterior to the larger valve. The cavity of the foot may be filled with water by relaxing the oblique sphincter musculature of the foot, which is then extended through the tight, thick mantle margin at the anterior end by progressive contraction of that musculature. The valves may regulate the passage of water at the posterior end of the animal, which has been described as a period of gentle, continuous intake followed by a sudden forceful ejection through the same opening. Presumably the valves are relaxed during intake, with the inward current produced by cilia on the circular ridges in the middle of the mantle cavity. Ejection may result from closure of the valves, followed by rapid retraction of the foot with simultaneous relaxation of the valves. This study is based on data submitted as a thesis for the Master of Science Degree in Biology at Texas A & M University, 1972.

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COMPARATIVE STUDIES ON THE DIGESTIVE AND REPRODUCTIVE SYSTEMS OF SOME MURICID GASTROPODS

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Twenty-four species of muricid gastropods collected from the intertidal zone of the coast of Taiwan, the Gulf of California (U. S. A.), Virginia (U. S. A.) and San Juan Islands (U. S. A.) were studied and compared. In the digestive system, differences were observed in the radula, accessory salivary gland and the stomach. In the reproductive system, differences were observed in the capsule gland, the prostate gland and the penis.

Radula. The rachidian tooth of the muricid radula can be divided into three types: (1) The *Thais* type: five-cusped (one central, two lateral and two marginal cusps), the lateral side of the lateral cusp has many and deeply cut denticles; found in the genera *Purpura*, *Drupa*, *Morula*, *Thais*, *Thaisella*, *Acanthina*, *Nucella*, *Urosalpinx* and *Eupleura*. (2) The *Murex* type: three-cusped (one central and two lateral cusps), lateral side of lateral cusp smooth; found in *Chicoreus*, *Hexaplex*, *Muricanthus* and *Mancinella*. (3) An intermediate type: three-cusped, but the angle of the margin somewhat raised to form a hump; the lateral denticles of the lateral cusp exist merely as wrinkles; found in *Morula granulata*.

Accessory salivary gland. Most muricid species have a pair of long accessory salivary glands, except for *Morula granulata* and *M. uva*, which have a pair of short, symmetrical or asymmetrical accessory salivary glands, and *Mancinella tuberosa*, *Drupella cornus* and *Thaisella rugosa*, which lack accessory salivary glands.

Stomach. All muricids examined had U-shaped stomachs, except *Drupa ricina* and *D. arachnoides*, which had a pouch on the esophageal side of the stomach.

Capsule gland. In cross-section the capsule gland could be assigned to one of four types: (1) Those species with a single left longitudinal fold (Fretter, 1941, *Jour. mar. Biol. Assoc. U.K.*, 25: 173-211) arising from the left lobe of the gland; anteroventral lobe lacking (*Morula granulata* and *M. uva*). (2) Those with a single left longitudinal fold arising at the junction of the left lobe of the gland and the ventral wall; anteroventral lobe present (*Drupa ricina*, *D. arach-*

noides, *D. morum* and *Chicoreus torrefactus*). (3) Those with a single left longitudinal fold arising from the ventral wall of the gland; anteroventral lobe present (*Thais distinguenda*, *T. kineri*, *Purpura luteostoma*, *Mancinella tuberosa* and *Acanthina angelica*). (4) Those with two or more longitudinal folds, the main left longitudinal fold arising from the left lobe of the gland; anteroventral lobe present (*Urosalpinx cinerea*, *Eupleura caudata*, *Thaisella rugosa*, *Nucella canaliculata*, *N. emarginata* and *N. lamellosa*).

Prostate gland. In cross-section the prostate gland could be assigned to one of three types: (1) Those species in which the lumen of the gland was round at the right ventral corner of the gland and the rectum is embedded in the gland (*Morula granulata*, *M. uva*, *M. borealis*, *Thaisella rugosa* and *Drupella cornus*). (2) Those in which the lumen of the gland was an extensive longitudinal slit and the rectum was free from the gland (*Drupa arachnoides*, *Thais distinguenda*, *T. kineri*, *T. armigera*, *Urosalpinx cinerea* and *Eupleura caudata*). (3) Those in which the lumen of the gland is multi-grooved and the rectum is free from the gland (*Nucella canaliculata*, *N. emarginata* and *N. lamellosa*).

Penis. Three types of penes were observed: (1) Those in which the basal portion was dorsoventrally flat and the distal portion thin and long (*Morula granulata*, *Drupa arachnoides*, *Thais distinguenda*, *T. kineri*, *T. armigera*, *Thaisella rugosa*, *Chicoreus torrefactus*, *Muricanthus nigrinus*, *Urosalpinx cinerea*, *Nucella canaliculata*, *N. emarginata* and *N. lamellosa*). (2) Those with the basal portion as in type 1, but the distal portion was club-shaped (*Purpura panama*, *P. luteostoma* and *Drupella cornus*). (3) Those with the basal portion as in type 1 but with an anteriorly projected pad, and the distal portion was either thin or thick (*Morula uva* and *M. borealis*).

The differences in morphology of the stomachs and accessory salivary glands do not serve as good systematic characters in muricid gastropods. However, the radulae and the reproductive systems are useful in determining systematic categories within the Muricidae.

NEW OUTBREAKS IN THE FLORIDA GIANT AFRICAN SNAIL INFESTATION

Albert R. Mead*

ABSTRACT

With the recent appearance of the giant African snail, Achatina fulica, in a third major infestation site in the Miami-Hollywood area, the problem that this snail has presented in Florida has now reached its most critical and possibly decisive stage since the original three year old infestation was discovered in 1969. Reports from the Indian subcontinent, Southeast Asia, and the Far East indicate that this snail pest is continuing to spread with no really effective means of control yet coming to light. Some wholly novel and exotic molluscicides have been recommended; some seem promising, but in most cases the results are still preliminary and empirical. Certain sophisticated physiological and histochemical investigations suggest strongly the possibility of their eventual use in highly selective molluscan metabolic antagonists. The widespread introduction of predatory snails, sciomyzid flies, and other types of predators as biological control agents is continuing to produce enigmatic results. The tissue inhabiting nematode, Angiostrongylus cantonensis (the causative agent of eosinophilic meningoencephalitis in humans), appears to be assuming a more and more important role as a stress factor in the disease syndrome. A predatory terrestrial planarian, Geoplana sp., has been discovered in Florida, but the nature of its predation on snails has not yet been determined.

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A PRELIMINARY REPORT ON THE NAIAD FAUNA OF THE CLINCH RIVER IN THE
SOUTHERN APPALACHIAN MOUNTAINS OF VIRGINIA AND TENNESSEE
(MOLLUSCA: BIVALVIA: UNIONOIDA)

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The Mississippi River system of central North America has the most diverse naiad mollusk fauna known. While the exact number of species found here is as yet uncertain, studies of the Ohio River system alone have revealed at least 120 species and subspecies. A consideration of the distribution patterns of these species demonstrates that they can be placed in three groups on a geographic basis (Ortmann, 1924, 1925). Some species are found generally throughout the Ohio basin. A second group is restricted to the Ohio River proper and its tributaries in the Central Lowlands and the Interior Low Plateau. These are referred to as the Ohioan fauna. A third group is found only in streams of the Tennessee and Cumberland River systems flowing out of the Southern Appalachians and the Cumberland Plateau. This assemblage is known as the Cumberlandian Fauna and has a number of elements analogous to the Ozarkian Fauna of the Ozark Plateau and Ouachita Mountains west of the Mississippi.

The Cumberlandian Fauna of the main stem of the Cumberland and Tennessee Rivers has been largely destroyed by impoundments, pollution, dredging operations and other activities which have greatly reduced or eliminated much of the naiad habitat. Field studies over the past decade have revealed that most species of this "high country" fauna still live in those few tributaries of the Cumberland and Tennessee Rivers that remain relatively unmodified. The fauna of the Clinch River above Norris Reservoir appears to be one of the best preserved of the entire area. This paper is a brief preliminary account of the naiad species found today in the Clinch River and some of its tributaries from its headwaters near Tazewell, Virginia, down to the head of Norris Reservoir near Tazewell, Tennessee. In spite of quantities of trash and obvious pollution in a number of places, this part of the river still retains most of the species recorded by Ortmann (1918) half a century ago (1912-1915). A concerted effort has been made to visit this free-flowing portion of the Clinch River at every bridge, ford, or other point of access at times of either normal or low water and to sample each of the habitat areas present.

Wherever possible the shell midden heaps left by

raccoon, muskrat or other mammals were salvaged and carefully checked. Such collections commonly contained a few to several hundred fresh-dead shells. Some middens containing over a thousand such specimens were found. Representative series of each species from each site studied are deposited in the Ohio State University Museum of Zoology.

Although data from other tributaries of the Tennessee and Cumberland Rivers are not presented here, it seems reasonably certain from our work in the area that the Clinch River has the greatest diversity of Cumberlandian species yet surviving. The 28 endemic species still living in the upper Clinch River are, with rare exception, found nowhere outside the Cumberland and Tennessee River systems. Some of these species are restricted to the Clinch River while others reach peak abundance here.

Every reasonable effort should be made to preserve this highly restricted, purely North American mollusk fauna. Present plans to improve the economic life of the people of Appalachia by the further impounding of these mountain rivers and the introduction of heavy industry into these valleys could easily destroy what little remains of this rare heritage.

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THE NAIADES OF THE CLINCH RIVER
ABOVE NORRIS RESERVOIR

C - Cumberlandian

P - Previously recorded (Ortmann, 1918)

(Collected by Adams, 1899 and Ortmann, 1912-1915)

O - Ohioan

R - Recently recorded (Stansbery, 1972)

(Collected by Stansbery and others, 1963-1971)

U - Undetermined

E - Believed extinct (Stansbery, 1970, 1971)

FAMILY MARGARITIFERIDAE Ortmann, 1911.

- 1.
- Cumberlandia monodonta*
- (Say, 1829).

Fauna

Recorded

U

R

FAMILY UNIONIDAE (Fleming, 1828) Ortmann, 1911.

SUBFAMILY ANODONTINAE (Swainson, 1840) Ortmann, 1910.

- 2.
- Strophitus undulatus shaefferianus*
- (Lea, 1852).

C

P R

- 3.
- Alasmidonta marginata*
- Say, 1818.

U

P R

- 4.
- Alasmidonta viridis*
- (Rafinesque, 1820).

U

P R

- 5.
- Pegias fabula*
- (Lea, 1836).

C

R

- 6.
- Lasmigona costata*
- (Rafinesque, 1820).

U

P R

- 7.
- Lasmigona holstonia*
- (Lea, 1838).

C

P R

SUBFAMILY AMBLEMINAE Morrison, 1955.

- 8.
- Quadrula cylindrica strigillata*
- (Wright, 1898).

C

P R

- 9.
- Quadrula sparsa*
- (Lea, 1841).

C

R

- 10.
- Quadrula intermedia*
- (Conrad, 1836).

C

P R

- 11.
- Quadrula pustulosa*
- (Lea, 1831).

U

P R

- 12.
- Ambelma plicata plicata*
- (Say, 1817).

U

P R

- 13.
- Fusconaia subrotunda lesueuriana*
- (Lea, 1840).

C

P R

- 14.
- Fusconaia cuneolus*
- (Lea, 1840).

C

P R

- 15.
- Fusconaia edgariana*
- (Lea, 1840).

C

P R

- 16.
- Fusconaia barnesiana*
- (Lea, 1838).

C

P R

- 17.
- Cyclonaias tuberculata*
- (Rafinesque, 1820).

U

P R

- 18.
- Lexingtonia dolabelloides*
- (Lea, 1840).

C

P R

- 19.
- Plethobasus cyphus*
- (Rafinesque, 1820).

U

P R

- 20.
- Pleurobema oviforme*
- (Conrad, 1834).

C

P R

- 21.
- Pleurobema coccineum*
- (Conrad, 1836).

U

P R

- 22.
- Pleurobema plenum*
- (Lea, 1840).

U

P R

- 23.
- Pleurobema pyramdatum*
- (Lea, 1831).

U

P R

- 24.
- Elliptio crassidens*
- (Lamarck, 1819).

U

P R

- 25.
- Elliptio dilatatus*
- (Rafinesque, 1820).

U

P R

- 26.
- Lastena lata*
- (Rafinesque, 1820).

U

P R

SUBFAMILY LAMPSILINAE (von Ihering, 1901) Ortmann, 1910

- 27.
- Ptychobranthus fasciolaris*
- (Rafinesque, 1820).

U

P R

- 28.
- Ptychobranthus subtentum*
- (Say, 1825).

C

P R

- 29.
- Cyprogenia irrorata*
- (Lea, 1828).

U

R

- 30.
- Dromus dromas*
- (Lea, 1834).

C

R

- 31.
- Actinonaias ligamentina orbis*
- Morrison, 1942.

C

P R

- 32.
- Actinonaias pectorosa*
- (Conrad, 1834).

C

P R

- 33.
- Truncilla truncata*
- Rafinesque, 1820.

U

P R

- 34.
- Leptodea fragilis*
- (Rafinesque, 1820).

U

P R

- 35.
- Potamilus alatus*
- (Say, 1817.)

U

P R

- 36.
- Toxolasma lividus lividus*
- (Rafinesque, 1831).

C

P R

- 37.
- Medionidus conradicus*
- (Lea, 1834).

C

P R

- 38.
- Ligumia recta*
- (Lamarck, 1819).

U

P R

- 39.
- Conradilla caelata*
- (Conrad, 1834).

C

P R

- 40.
- Villosa fabalis*
- (Lea, 1831).

U

P R

- 41.
- Villosa trabalis*
- (Conrad, 1834).

C

P R

42. <i>Villosa perpurpurea</i> (Lea, 1861).	C	P	R
43. <i>Villosa iris nebulosa</i> (Conrad, 1834).	C	P	R
44. <i>Villosa vanuxemi</i> (Lea, 1838).	C	P	R
45. <i>Lampsilis ovata</i> (Say, 1817).	U	P	R
46. <i>Lampsilis ventricosa</i> (Barnes, 1823).	U	P	R
47. <i>Lampsilis fasciola</i> Rafinesque, 1820.	U	P	R
48. <i>Epioblasma triquetra</i> (Rafinesque, 1820).	U	P	R
49. <i>Epioblasma brevidens</i> (Lea, 1831).	C	P	R
50. <i>Epioblasma haysiana</i> (Lea, 1834).	C	P	R
51. <i>Epioblasma lenior</i> (Lea, 1843).	C	P	E
52. <i>Epioblasma stewardsoni</i> (Lea, 1852).	C	P	E
53. <i>Epioblasma capsaeformis</i> (Lea, 1834).	C	P	R
54. <i>Epioblasma walkeri</i> (Wilson and Clark, 1914).	C		R
55. <i>Epioblasma torulosa gubernaculum</i> (Reeve, 1865).	C	P	R

NAIAD SPECIES RECORDED ONLY FROM THE LOWER (IMPOUNDED)
SECTION OF THE CLINCH RIVER (COLLECTIONS MADE BEFORE
IMPOUNDMENT)

56. <i>Fusconaia subrotunda subrotunda</i> (Lea, 1831).	U	P	
57. <i>Pleurobema cordatum</i> (Rafinesque, 1820).	U	P	
58. <i>Obliquaria reflexa</i> Rafinesque, 1820.	U	P	
59. <i>Plagiola lineolata</i> (Rafinesque, 1820).	U	P	
60. <i>Obovaria retusa</i> (Lamarck, 1819).	U	P	
61. <i>Leptodea leptodon</i> (Rafinesque, 1820).	U	P	
62. <i>Lampsilis orbiculata</i> (Hildreth, 1828).	U	P	
63. <i>Epioblasma arcaeformis</i> (Lea, 1831).	C	P	E
64. <i>Epioblasma lewisi</i> (Walker, 1910).	C	P	E
65. <i>Epioblasma propinqua</i> (Lea, 1857).	C	P	E

While the details concerning each of the above species are beyond the scope of this report, some statistics may be of interest.

Number of species and subspecies previously recorded from the upper Clinch River (Ortmann, 1918) . . .	49
New Records for the upper Clinch River contained herein . . .	6
Total species and subspecies recorded from the upper Clinch River . . .	55
Additional species recorded from the lower Clinch only (prior to impoundment) . . .	10
Total species and subspecies recorded from the Clinch River . . .	65
Species recorded from the Clinch River believed extinct . . .	5
Species believed living in the Clinch River today . . .	60
Species of Cumberlandian origin recorded from the Clinch River . . .	33
Species of undetermined origin recorded from the Clinch River . . .	32
New records for the Clinch River contained herein . . .	3*

**Pegias fabula*, *Quadrula sparsa*, and *Epioblasma walkeri*.

NEGLECTED TOPOGRAPHICAL RELATIONSHIPS BETWEEN THE GILL AND SHELL OF BIVALVE MOLLUSKS

Harold W. Harry*

Several principles of organizations of the excurrent mantle chamber of bivalve mollusks, which are of prime importance in understanding the functional anatomy and phylogeny of the group, have been neglected in the literature.

The gill axes in bivalves are two parallel lines, usually straight but sometimes curved (particularly in the asiphonate monomyaria), along which arise the paired gill elements, either the lamellae of the protobranchs or filaments of the filiobranchs and eulamellibranchs. The front part of the axes are extensively adnate to the visceral mass, but the posterior ends of the axes extend free behind the visceral mass for a varying distance. The posterior, free extension is longer in more primitive forms (Protobranchia, Arcacea, *Trigonia*, Pseudolamellibranchia). In most of the latter forms, each gill axis is suspended by a muscular septum, which can contract to draw the gills upward, thus effecting a pumping action. The gill elements extend from the axes to the mantle laterally, and to the visceral mass medially, where they effect functional (non-fused) or structural (fused) junctions. These junctions, together with the gill axes and intervening gill elements, define the gill diaphragm, or partition between the incurrent and excurrent chambers of the mantle cavity. Behind the gill axes the diaphragm is sometimes augmented by a small ingrowth of the fused inner lamellae of the mantle margin.

Particulate matter which enters the incurrent mantle chamber is effectively denied passage to the excurrent one by the gill diaphragm. Feces, urinary products and gametes (in most) are shed into the excurrent chamber, and are removed by the same stream of water, initiated by the gills, which brings water into the incurrent mantle chamber. Sudden contraction of the adductor muscles augment water movement, always forcing water out of both chambers of the mantle cavity. When the adductor muscles are relaxed, the same amount of water enters and leaves the mantle cavity in unit time. But the excurrent stream is always faster and more forceful than the incurrent one. This results from the following principles:

(1) The excurrent opening of the mantle cavity of bivalves is always smaller than the incurrent one. Moreover, the excurrent chamber is always smaller in volume than the incurrent chamber of the mantle cavity. These arrangements are accomplished in more

primitive members of the class by the position of the gill axes in relation to the mantle and shell, as follows:

(2) The anterior ends of the gill axes of bivalves originate at the level of the umbos or slightly behind the umbos. When the umbos are far forward, the front end of the gill axes may be far behind them. In those cases in which the front ends of the gill axes are not located directly under the umbo (*Ensis*, asiphonate monomyarians), each umbo is on a line which is an extension of the gill axis.

(3) Originally, and in most bivalves, the posterior ends of the gill axes are approximately just above the part of the shell margin where the post-dorsal slope of the shell's periphery joins the ventral part of the shell margin; or, in rostrate species, the hind end of the axes end in the middle of the rostrum.

Siphons seem to have evolved independently several times in the bivalvia. Although varied in structure, length and terminal appendages in different groups, the excurrent siphon always appears before the incurrent one, and in many bivalves it is the only one present. It serves to reduce further the excurrent opening, relative to the incurrent one. When the entrance of water is limited by a second siphon, the opening of that siphon is always larger than that of the excurrent one. These mechanisms further enhance the flushing ability of the excurrent stream of water.

In most bivalves, the front end of the gill axes retain their position subordinate to that of the umbos, regardless of changes in the shape of the shell (Figs. 1-11). In species in which the umbos are distant from the front end of the animal, the connection between the gill surface and the mouth is made by lengthening the gill filaments or the labial palps or both. This varies widely in different groups. But the front end of the gill axis can only approach the mouth in forms in which the umbos are near the anterior margin of the shell.

A major exception to these generalizations may be the septibranchs, which according to drawings in the literature, have centrally placed umbos, but the diaphragm extends far in front of them. The relative size of the two mantle chambers and the siphonal openings in septibranchs seem to be in accord with the principles stated above.

In oysters (Fig. 9) the principles hold very well. The occlusion of the promyal chamber on the right side which occurs in some genera of oysters (it is occluded on the left in all species of the family) is an

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additional method of decreasing the volume of the excurrent mantle chamber.

In Tridacnidae (Fig. 11), most of the principles are valid, despite much shifting of position of the gills and other structures, and loss of the anterior adductor muscle. The anterior end of the gill remains at or slightly behind the umbos, which are a short distance behind the middle of the shell's length. The front ends of the gill axes have swung forward nearly 180° , however. But the excurrent siphon is smaller than the incurrent, and the excurrent mantle chamber is smaller in volume than the incurrent one. As also occurs in

oysters, it is the mouth which has moved to the front end of the gill axes, rather than the opposite.

Many anatomical drawings of bivalves in the literature seem to be wrong in their placement of the gill axes. Others do not adequately show the position or extent of the axes because they are obscured by the profile of the outer demibranch, which sometimes extends in whole or in part dorsal to the axes themselves. Such an extension is an additional mechanism which reduces the volume of the excurrent mantle chamber, thereby enhancing flushing ability of the excurrent stream of water.

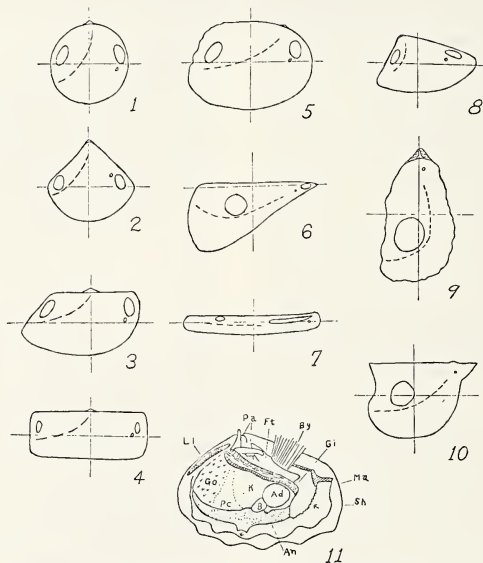


PLATE 3. All species are viewed from the right side.

Heavy dashed lines represent gill axes. The small circle near the anterior margin of the shell is the approximate position of the mouth. Larger circles are the adductor muscles. 1, *Glycymeris*; 2, *Crasinella*; 3, *Arca*; 4, *Tagelus*; 5, *Amblema*; 6, *Pinna*; 7, *Ensis*; 8, *Donax*; 9, *Ostrea*; 10, *Pteria*; 11, *Tridacna* (after Purchon 1955, Proc. Mal. Soc. London 31: 97). Ad, Adductor muscle; An, Anus; B, Byssal retractor muscle; By, Byssus; Ft., Foot; Gi, Gill; Go, Gonad; K, Kidney; Li, Ligament; Ma, Mantle; Pa, Labial palps; Pc, Pericardium; Sh, Shell; Incurrent and excurrent siphons are shown by arrows. The excurrent mantle chamber is darkly stippled.

MOLLUSCAN POPULATION OF A SUBMERGED REEF OFF PADRE ISLAND, TEXAS¹

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Seven and One-half Fathom Reef is a small topographic prominence located in the shallow neritic waters of the northwestern Gulf of Mexico. It lies 74 kilometers south of the northern entrance to Padre Island National Seashore and 3.2 kilometers offshore from Padre Island in 14.0 meters of water.

The reef is an elongate sedimentary rock structure composed of a silty quartz sandstone that is partially cemented with calcium carbonate. It is approximately 350 meters long and averages about 50 meters in width with a maximum relief of 5.4 meters. The general topography is rough, with numerous crevices and small caverns. The sides vary from steep cliffs, dotted with pockets, to even, gentle slopes. Boring molluscs and other organisms have extensively eroded the upper levels of the structure, and sponges, hydroids, bryozoans and algae have completely encrusted it. Fossil mammal teeth and bones found in the crevices (Tunnell and Causey, 1969) and fossil freshwater snails in the rock indicate the reef is of terrestrial origin.

Bottom salinities adjacent to the reef during the study varied from 28.1 to 35.9 ppt. Temperature ranged from a low of 13.2°C in the winter to a high of 30.1°C during the late summer.

The molluscan fauna of Seven and One-half Fathom Reef was studied during 1968-1969. SCUBA was employed as a working tool and proved to be a way of adequately sampling this hard-rock structure and of collecting life history data on animals in their natural habitat.

Three sampling methods were utilized for collecting molluscs: 1) mud samples from the crevices and surrounding bottom, for representative micro-molluscs associated with the structure; 2) rock samples, for boring and attached species; and, 3) random collecting by hand, for mobile macromolluscs. In the last method most of the reef surface was examined *in situ*, turning over rocks and searching crevices and holes. Relative abundance of some of the larger, more common species was obtained by taking meter square quadrats along transects set across the reef. In addition, sponges, hydroids and algae were collected, washed and examined for small molluscs.

Using these three sampling methods 169 species of molluscs were found representing 71 families. There were 108 gastropods, 57 bivalves, 3 scaphopods and 1 cephalopod (Tunnell and Chaney, 1970).

Of the 97 species of micro-molluscs identified in the mud samples, the following were the most abundant; cf. *Cingula sandersoni* Verrill (shells only), juvenile (turritella stage) *Vermicularia spirata* Philippi, *Tectonatica pusilla* (Say), *Anachis obesa* (C. B. Adams) and *Abra aequalis* (Say). The shells and valves of a number of other species were also quite abundant: *Parviturboides interruptus* (C. B. Adams), - *Anachis* sp., *Retusa canaliculata* (Say), *Cylichna bidentata* (d'Orbigny), *Odostomia seminuda* (C. B. Adams), *Cresis aspicula* (Rany), *Lucina multilineata* (Tuomey and Holmes), *L. amiantus* (Dall), *Chione grus* (Holmes), and *Corbula contracta* Say.

The most abundant boring pelecypod in nearly all rocks examined was *Lithophaga bisulcata* (d'Orbigny). As many as 158 individuals were removed from a single rock measuring 140 x 140 x 400 mm. *Gregariella coralliophaga* (Gmelin) was the second most abundant "borer" (actually found embedded in its own secretion of fibers and accumulated sand, not bored into rock). As many as 72 individuals were counted on a single rock measuring 160 x 180 x 380 mm. An average of three *Rupellaria typica* (Jonas) was found in each rock examined and *Lithophaga aristata* (Dillwyn), *Diplodonta punctata* (Say) and *Roccellaria hians* Gmelin (valves only) were represented by one individual in every 5-8 rocks. The sipunculid *Phascolosoma antillarum* Grube and Oersted was also common in most rocks. Fifty individuals were removed from one rock.

The most abundant large pelecypod attached to the reef was *Arca imbricata* Bruguière. It was most abundant, up to 287 individuals in one square meter, on the upper levels of the reef. *Arca zebra* (Swainson) was also present, but much less abundant than *A. imbricata*. *Barbatia domingensis* (Lamarck) was also very abundant, as many as 64 individuals were counted attached to one rock measuring 140 x 140 x 400 mm. *Ostrea equestris* Say was found in abundance on the lower seaward side of the reef where 336 individuals were counted on rocks in one square meter of one transect. Live individuals and shells of this species literally covered most rocks along the entire bottom length of this side of the reef. However, this species

¹ This research was conducted under Texas A & I University Faculty Research Grants 449-G-68 and 449-4-69.

was not found anywhere else on the reef. An explanation for this odd phenomenon is not clear at present. *Chama congregata* Conrad was also quite abundant attached to rocks and other shells.

Other macro-pelecypods which occurred alive and are not commonly found along the usual mud-sand substrate of most of the Texas coast were: *Atrina rigida* (Solander), *Pteria colymbus* (Röding), *Lyropecten nodosus* (Linné), *Spondylus americanus* Hermann, *Pododesmus rudis* (Broderip) and *Pseudochama radians* (Lamarck).

Abundant gastropods were *Calliostoma euglyptum* (A. Adams), *Cypraea cervus* Linne, *Thais haemostoma* (Linné), *Anachis avara* (Say) and *Pisania tinctus* (Conrad). *C. cervus* was a cryptic species and usually observed moving about in crevices or under large rocks. Ten to fifteen of these large cowries could be seen in one dive if these areas were examined. *C. euglyptum* was usually found under rocks and in pockets on the sides of cliffs. *T. haemostoma* was generally found on the underside of rocks or moving about over small rock piles. In July 1968 five individuals were noted laying eggs on two *Leptogorgia virgulata* Lamarck in approximately 11 meters of water. On that same day three other individuals were noted laying eggs on a branching hydroid. *P. tinctus* was usually found on the underside of rocks on all portions of the reef. Egg cases of this species were found attached to rock samples collected during July 1968. The small snail *A. avara* was commonly found all over the reef.

Other species associated with this reef, but uncommon or unreported along most of the Texas coast were: *Neosimnia acicularis* (Lamarck), *Cyphoma mcgintyi* Pilsbry, *Cymatium pileare* (Linné), *Bursa cubaniana* d'Orbigny and *Chicoreus pomum* Gmelin.

Octopus vulgaris Lamarck was the largest and most voracious molluscan predator observed on the reef. In one instance this octopus was observed carrying a live *Cypraea cervus* into its den. On another occasion one was seen struggling with a large *Pleuroploca gigantea* (Kiener). Each individual observed had a den within a large rock or crevice that could repeatedly be visited and observed in the same location on various trips to the study area. Fresh shells observed immediately outside of octopus dens and presumably eaten by them were: *Cypraea cervus*, *Oliva sayana* Ravenel, *Arca zebra*, *A. imbricata*, and *Barbatia candida* (Helbling).

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SOME NOTES ON SEXUAL DIMORPHISM IN THE SHARK EYE, *POLINICES DUPLICATUS* (SAY) AT ROCKAWAY BEACH, NEW YORK

Morris K. Jacobson*

There is little mention in the literature of the fact that the Shark Eye, *Polinices duplicatus* (Say), at least toward the center of its range, occurs in two distinct forms. This dimorphism is very noticeable in many specimens in the population at Rockaway Beach, New York, but in many cases, especially in medium sized shells, it is less so. Some shells are quite flat with a low, domelike spire. Others have a sharply raised, triangular or pyramidal shape with the spire strongly raised; the latter are in addition heavier than the former. The difference between the two types of shells is so strong that Smith & Prime (1870: 396) thought that "two species are probably included under [one] name."

According to Dall (1892: 369) this difference is a secondary sexual characteristic, the higher and heavier shell being the male, the lower, lighter one the female. I was able to confirm this by examining some live specimens at Rockaway. It occurred to me that it might prove of interest to try to express this shell dimorphism mathematically and to see if the less strongly marked shells can statistically be fitted into the picture.

Bernard (1968) reported on the measurements of sexual dimorphism in a related naticid on the West Coast, *Polinices lewisi* (Gould). Though Bernard found no difference in the shell outline such as occurs in *P. duplicatus*, he did find that "the shells of males, particularly the older ones, were proportionately thicker than those of the same sized females." (loc. cit., 3). He further noticed that this difference grew greater as the snails matured. At Rockaway, however, the difference was noticeable in even some smaller shells.

I have worked with three characteristics in my study of the Rockaway specimens: the height/diameter index (h/d), the angle of diversion of the spire, and the volume/weight index (v/w). The last is arrived at by dividing the product of the height and the diameter, loosely called the volume, by the weight. So far the statistical results are too meager to reach any conclusion. Nevertheless, a brief preliminary report might prove of interest.

For the purpose of this preliminary report, I se-

lected three pairs of shells, each pair of approximately the same size, but one of each pair distinctly male, the other female. The largest pair measured about 63 mm in diameter, the medium pair about 49, the smallest about 40. Applying the three measurements to each of these pairs, I found the following results:

h/d index		
male	female	
.900	.846	smallest pair
.827	.920	medium pair
.920	.951	largest pair
Here we see no significant difference between the male and female shells.		

v/w index		
male	female	
49.7	67.3	smallest pair
39.8	70.8	medium pair
36.5	69.1	largest pair
Here the difference is significant, the male being distinctly heavier. The v/w index for the heavier male is, of course, lower because the greater weight goes fewer times into the volume.		

angle of divergence		
male	female	
90°	110°	smallest pair
100°	110°	medium pair
100°	110°	largest pair
Here the male is clearly more acutely conical than the female.		

These results indicate that there is indeed a secondary sexual dimorphism at least in the extreme shells. It now remains to be seen whether this difference is maintained when less distinctly differentiated shells are taken into consideration.

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PARALLEL EVOLUTION OF SHELL CHARACTERS IN SUCCINEIDS INHABITING WATERFALLS¹

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ABSTRACT

Most representatives of the stylommatophoran family Succineidae are terrestrial residents in humid habitats. Many species are amphibious, while some are arboreal and others are adapted to living in extremely dry areas. At least two species, *Lithotis rupicola* and *Succinea bernardii*, are found living aquatically on the vertical faces of rocks at waterfalls. The shells of these two anatomically distinct generic forms have evolved to become so peculiarly similar that, based on shell characters alone, they would most likely be considered closely related. This is undoubtedly why Zilch (1959, in: Schindewolf, Handbuch der Palaozoologie, Lief. 1 (6): 1-701) placed both *L. rupicola* and *S. bernardii* together in a third genus, the conchologically similar *Camptonyx*. In fact, *S. bernardii* was placed in *Camptonyx* s. s. The anatomy of *Camptonyx* has not been studied.

Lithotis rupicola was collected from the vertical face of algae-covered rocks, a short distance from the major waterfall at Khandalla in the Western Ghats, India, in June 1968. Water flows down the rock wall and over the snails, so that *Lithotis* actually lives in an aquatic environment. The most prominent feature of the shell of *L. rupicola* is a raised spiral ridge which shields the pneumostome at the apertural margin. I refer to this feature as the pneumostomal ridge. This ridge aids in channeling water over the shell to either side of the ridge, thereby providing an air space around the pneumostome. Thus, the animal can live in an aquatic habitat and remain an air breather. Furthermore, the shell has become depressed or almost limpet-like in form, allowing less resistance to water flow, which would otherwise tend to dislodge the snail from the vertical rock surface. Along with the depressed shell is an accompanying large aperture which entirely accommodates the broad foot. The animals move about with only the tentacles protruding slightly from beneath the shell margin, which keeps the water from "catching" the edge of the shell and dislodging the animal.

The Tahitian *Succinea bernardii* was collected from a similar habitat as the Indian *Lithotis*, near a waterfall in Fautau Valley on the island of Tahiti. The shell of *S. bernardii* strongly resembles that of *L. rupicola* in being similarly depressed and having a prominent pneumostomal ridge.

A pneumostomal ridge is also present on a species of *Succinea* living in the spray zone of a waterfall in Papenoo Valley, Tahiti, and on a species of *Succinea* living in the spray zone of Thomson's Falls, Kenya. Neither of these species lives directly in running water nor do they have depressed shells. However, since water does continually collect on the shell surface, they too have evolved a pneumostomal ridge to channel water away from the pulmonary opening.

These are interesting shell characteristics which have evolved independently in the Succineidae as adaptations which aid some members of this worldwide group in occupying aquatic or semi-aquatic habitats that would otherwise be unsuitable for them. Such adaptations in the shell undoubtedly accompany other physiological, morphological and behavioral traits.

¹ Research supported by N. I. H. Training Grant No. 5 T1 AI 41 from the National Institute of Allergy and Infectious Diseases, U. S. Public Health Service, Grant GB-6450 (to Dr. Yoshio Kondo) from the National Science Foundation, and a grant from the Foreign Currency Program, Office of International Activities, Smithsonian Institution.

FIELD NOTES AND CORRESPONDENCE OF JOHN K. STRECKER (1875-1933)

Harold D. Murray*

From March 6-9, 1972, I studied the naiad collection at the Strecker Museum, Baylor University, Waco, Texas. John K. Strecker was an early Texas naturalist whose main interests were herpetology, ornithology, and malacology. Strecker (1931) published a list of the Texas naiads which is today the most complete listing for the state. The naiad collection of the Strecker Museum is mostly disorganized and presently contained in some 21 cardboard boxes of assorted sizes.

There are no dates of collection on the specimens, on the museum labels, or in the catalogues for the naiads in the Strecker Museum. Dr. Bryce Brown, Director of the Museum, suggested I search the field notes and correspondence of Strecker to determine the dates of collection. I believe this is the first examination of Strecker's correspondence pertaining to mollusks.

The earliest field note indicating a naiad collection by Strecker was June 11, 1906 for specimens from the North Bosque River, McLennan County, Texas. No naiad collected by Strecker should have a date earlier than this, and the correspondence to follow confirms this opinion. April 3, 1932 was the final field note entry for naiads from the Cibolo Creek, 21 miles north of San Antonio, Texas.

I divided Strecker's malacological correspondence into three periods. The first period, October 14, 1906 to March 29, 1908, was a time of identification by authorities and exchange of Texas naiads. The second period was from March 29, 1908 to March 11, 1912, when he apparently had no interest in naiads. During the third period, March 11, 1912 until his death January 9, 1933, there was considerable interest in naiads. The reader should realize that the correspondence was only letters written to Strecker and that I have either paraphrased or quoted parts from these letters.

A. The first period - October 14, 1906 to March 29, 1908.

Only five letters in this period mentioned naiads with the first dated October 14, 1906, from W. E. Snyder who wished to exchange shells. The four month interval between the field date on June 11, 1906 and this letter confirms the field date of June 11 as the first naiad collection by Strecker. N. W. Lermond (June 30, 1907), later secretary of the AMU, and R. Rathbun (September 9, 1907), Assistant Secretary of the U. S. National Museum,

both wrote to indicate their desire to receive Texas naiads.

On October 25, 1907, Berlin H. Wright wrote concerning Strecker's desire to exchange Texas naiads. The following from that letter is both interesting and revealing, "I have every species of naiad from Texas in my collection; therefore do not need yours. I will, however, send you duplicates of my material when I get back to my collection."

The last letter in this period was the first letter from Bryant Walker dated March 24, 1908. Among other things Walker stated, "... *Lampsilis purpuratus* is not species but typical *berlandieri*." I believe that the *L. purpuratus* mentioned involved specimens of the first recorded field date (June 11, 1906) because in the margin of his field notes Strecker wrote in different pen, "most of these are *berlandieri* according to Walker."

B. The second period - March 24, 1908 to March 11, 1912.

During this period, there were no letters received by Strecker referring to naiads. Apparently Strecker neither collected nor exchanged naiads during this four year period; therefore, specimens collected by Strecker should bear no dates for this period.

C. The third period - March 11, 1912 to 1933.

The second period ended with a letter from Bryant Walker dated March 11, 1912, indicating that Walker had forwarded naiads to Strecker.

Although J. D. Mitchell wrote numerous letters to Strecker concerning herpetology and entomology, the letter of March 27, 1912 was the first letter by Mitchell to mention naiads, and stated, "... You will find Mr. Frierson is authority on Unios. He is one of the finest 'all around' men I ever met." Apparently, Mitchell introduced Strecker to Frierson.

The first letter from L. S. Frierson to Strecker was dated August 5, 1912 (five months after Mitchell's letter). Frierson noted that he was glad that Strecker was working on a checklist of Texas Shells, and that he (Frierson) had finished one for North America and worked on it for two years. The correspondence between Frierson and Strecker was numerous after August 5th. What started as a polite, nonpersonal relationship changed rapidly to a warm, personal relationship between the two with each spending many days in the home of the other. This was the only professional relationship that became personal in the correspondence.

Frierson wrote too many letters to detail them all; however, the following may interest many. Frierson

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wrote on June 10, 1916, ". . . I want one or two pairs, if possible of live *Unio Berlandieri*, Lea, sent with my compliments to Dr. A. E. Ortmann, Carnegie Museum, Pittsburg, and send me the bill. If possible, I would like to see a gravid female myself. But the Doctor doesn't need that they be gravid. He can tell how they ought to look, with his glasses! Be sure he gets a female." (The underscoring is Frierson's). Both Frierson and Strecker were having difficulty with *U. berlandieri* which was the complex I was examining at the museum. There were no letters from Ortmann or Frierson that they ever received these specimens.

It is unfortunate that there are no dates for the naiads in the Strecker Museum. If one can correlate the volume of correspondence on naiads to activity of collecting naiads, it is reasonable to assume that no

naiads were collected by Strecker from early 1908 to early 1912 and that the majority were collected between 1912 and 1932. Unfortunately, I see no way, at present, of refining almost 21 years of collecting by Strecker.

This study was done with the aid of a grant from the Faculty Research and Development Council of Trinity University. I wish to thank Dr. Bryce C. Brown, Director of the Strecker Museum, for his cooperation during this study.

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ASPECTS OF MOLLUSCAN ZOOGEOGRAPHY IN BAFFIN BAY AND THE GREENLAND SEA

Arthur H. Clarke*

Shallow-water marine mollusks from the vicinity of Greenland have engaged the attention of naturalists for 200 years. It is therefore surprising that only two archibenthal or abyssal biological bottom samples have ever been reported from off the west coast of Greenland in Baffin Bay (Lemche, 1941; Thorson, 1951). On the basis of these samples Thorson (loc. cit.) described two new species, however, and postulated the existence of a partly endemic fauna in the abyssal basin of Baffin Bay, isolated from the Labrador Sea by a 300 fathom sill at Davis Strait.

In order to test this hypothesis, the writer made arrangements with the Bedford Institute of Oceanography to carry out dredgings in Baffin Bay aboard C. S. S. *Dawson* and C. S. S. *Hudson* in 1970 and 1971. For comparative purposes, and through the courtesy of the U. S. Naval Oceanographic Office, dredgings were also carried out in 1971 aboard U. S. S. *Lynch* in the Labrador Sea and the Greenland Sea and in the vicinity of Iceland. I am grateful to these institutions for their support, to Mr. Brian T. Kidd for reliable assistance in the field, and to Mrs. Muriel F. I. Smith and Mrs. Jane Topping for conscientious assistance in the laboratory.

A total of 24 dredge hauls were taken in Baffin Bay and 23 were taken in the Labrador and Greenland Seas, mostly from archibenthal and abyssal depths. 174 species of mollusks were collected. A full report is in preparation but a few of the observations and conclusions will be presented here.

ENDEMICITY IN BAFFIN BAY

The material now available shows that the Baffin Bay fauna is closely related to that of the Labrador Sea and although it is reduced in number of species the Baffin Bay fauna is essentially an extension of the Labrador Sea fauna. The presence of some endemic mollusk species occurring in depths greater than 300 fathoms, i.e. greater than the sill depth of Davis Strait, suggests substantial antiquity of isolation of the archibenthal and abyssal fauna there. These species are *Acrybia glacialis* Thorson, *Colus krampi* (Thorson), and some other species which may be new, i.e. *Proneomenia* sp., *Chaetoderma* sp., and *Lyonsiella* sp. Presumed antiquity is in agreement with the most recent estimates of age for the termination of sea-floor spreading in Baffin Bay and the for-

mation of the Davis Strait sill, i.e. about 60 million years ago (Keen *et al.* 1972).

THE EUROPEAN-NORTH AMERICAN FAUNAL BOUNDARY

Initial examination of the molluscan fauna dredged near Iceland showed that it was quite different from that dredged in Baffin Bay and along the coast of North America. Several genera and species were present which do not occur in the western Atlantic, e.g. *Emarginula fissura*, *Aporrhais serresiana*, *Nassarius incrassatus*, *Arca nodulosa*, *Modiolus phaseolinus*, *Chlamys septemradiatus*, *Hinnites distorta*, *Parvicardium* spp., *Venus casina*, *Gari* spp., etc. The available distributional data on northern prosobranch gastropods (Thorson, 1944; Macpherson, 1971) and on northern lamellibranchs (Ockelmann, 1958) from all depths, together with other data, were then analyzed to determine more fully the nature and magnitude of this faunal change.

The analysis showed that a dramatic change in the faunal composition does occur along the island arc. If pan-boreal species and those known only from Greenland and/or Iceland are excluded, the faunal shift may be expressed in a striking manner by using the percentage of "European" species relative to the total of "European" plus "North American" species in the faunas of West Greenland, East Greenland, Iceland and the Faroes. These percentages are 22%, 41%, 88% and 100% respectively. The most dramatic shift occurs as one progresses from East Greenland to Iceland, and it is caused principally by the large increase (78) of "European" species and only secondarily by a decrease (16) in "North American" species. Such changes may be more apparent to a North American worker than to a European. On zoogeographic grounds, therefore, the island arc may be considered as a region of transition between the North American and European faunas and, if it is desirable to designate a boundary line between these zoogeographic regions, the line should be located between East Greenland and Iceland.

DYNAMIC ZOOGEOGRAPHY

It is usually difficult, and often impossible, to decide whether new regional records for species are the result of more thorough and/or more effective collecting methods or if they signify migrations of the species concerned. When large or conspicuous species

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are found in areas which have been well studied previously the probability appears great that faunal migrations have occurred. Present examples of this are new records of *Laecocochlis granosa* (Wood) from near the Grand Banks, *Neptunea satura* (Martyn) from near Iceland, and *Megayoldia thraciaeformis* (Storer) from the northern extremity of Baffin Bay. On the other hand new records of small inconspicuous species may not reflect faunal migrations, although the possibility of such migrations surely exists. Examples here are the new records for *Aclis walleri* Jeffreys (near Iceland), *Eulimella compactilis* Jeffreys (Davis Strait), and *Axinulus pygmaeus* (Verrill and Bush) (Baffin Bay).

Natural range expansions of some marine animals are well documented and there is every reason to believe that the zoogeography of archibenthal and abyssal molluscs is also dynamic. Our present concepts of geographic distribution patterns of deep-water marine molluscs are based on summations of all presumably authentic species records accumulated over 50 to 100 years or more. The extent to which these conceptual patterns reflect present reality is an important question which deserves investigation.

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THE AMERIPAGOS EXPEDITION

Twila Bratcher *

The purpose of the Ameripagos Expedition was to study the molluscan fauna of the Galapagos Islands with emphasis on those within scuba or snorkle diving range and on the Opisthobranchia. Both areas had been neglected by former expeditions. Only one species of nudibranch had been reported from that area. Ellen Brennan, Jackie Grundman, David Mulliner, William Old, Carolyn Polonsky, Gale Sphon and myself, Twila Bratcher, spent the month of March 1971 based at the Charles Darwin Research Station at Academy Bay, Santa Cruz Island with field trips to 10 other islands.

Planning for the expedition began in July 1969, nearly one and a half years before our arrival in the Galapagos. We received permission from Captain Sir Thomas Barlow, Secretary General of the Charles Darwin Foundation for UNESCO, to use the facilities of the Darwin Station. This eliminated the necessity of obtaining a special collecting permit from the Galapagos National Park Service.

The Galapagos archipelago, 600 miles west of Ecuador, is surrounded by water warm enough for diving only about three months of the year even though it straddles the equator. During the remainder of the time the Humboldt Current from the antarctic brings water so frigid that even the air of the islands is cooled. Around the first of the year the Humboldt Current is replaced by the warmer Panama Current. Fur seals and penguins co-exist with tropical fish and corals. We recorded surface water temperatures there as high as 80°F.

The divers carried underwater slates on which were recorded such observations as: *Conus diadema* Sowerby, 1834, were depositing square pink eggs, and we noticed a number of *Engina pyrastoma* (Sowerby, 1832) on the eggs but could not be sure they were feeding. *Cerithium adustum* Kiener, 1841, were copulating and depositing eggs like small white dots attached to threads. *Thais melones* (Duclos, 1832) were feeding on *Cerithium adustum*. When a piece of calcareous coral broke away from the rock to which it was attached, we discovered the habitat of *Colubraria lucasensis* Strong & Hertlein, 1937, underneath and completely covered by coral where it was attached to the rock.

By intertidal and diving collecting we recorded 25 species of nudibranchs. Six of those are probably new and are being researched by Dave Mulliner and Gale Sphon.

The few beds of *Caulerpa* we discovered contained both *Lobiger souverbii* Fischer, 1857, and the bivalved gastropod, *Berthelinia chloris* (Dall, 1918).

The personnel at the Charles Darwin Research station were most helpful. They furnished us with laboratory space and equipment and desk space. They loaned us camping gear for a field trip when our own equipment was late arriving, and they offered suggestions for field trip locations and helped us in many other ways.

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SYMPOSIUM ON GENETICS, CYTOGENETICS AND HYBRIDIZATION OF MARINE MOLLUSKS

J. B. Burch, Convener

The seven papers which were read at this symposium are summarized below as abstracts or presented

in condensed form. The full papers will be published in Malacological Review, vol. 6, no. 2, 1973.

CYTOGENETICS OF GASTROPOD MOLLUSKS¹

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ABSTRACT

Cytogenetic studies of gastropod mollusks have been concerned with hybridity, polyploidy, chromosome morphology and behaviour, karyotype studies, sex chromosomes and supernumerary chromosomes. A detailed review of these can be found in Patterson (1969, Proc. Symp. Moll., Pt. 2, Mar. biol. Assoc. India, p. 635-686).

Hybridity.

*There are only three purely cytogenetic studies of hybrid snails known to me; those of Staiger (1954, Chromosoma, 6: 419-478), Burch (1964, Amer. malacol. Union, ann. Reps., 31: 28-29), and current researches under way in our laboratories at The University of Michigan. Staiger studied various populations of the muricid snail, *Purpura lapillus*. In hybrid populations between $n=13$ and $n=18$ forms, individuals were found in which, during meiosis, five metacentric chromosomes paired with ten acrocentrics. Presumably the ten acrocentrics arose by splitting of the centromeres of five metacentric chromosomes.*

*Burch (1960, Amer. malacol. Union, ann. Reps., 26: 15) reported the chromosomal features of four nominal species of *Oncomelania*, and later (1964, op. cit.) studied the cytology of hybrids of the four so-called species. From his results, the non-reduced viability of the hybrids and the morphological similarities of the parental populations, Burch concluded that the four nominal species, although isolated and widely separated geographically, were in reality only races of one species.*

*The third cytogenetic study is one currently in progress in our own laboratories in Ann Arbor. We are studying the karyotypes of hybrid offspring from matings of *Bulinus* (*Isidora*) species having diploid and polyploid chromosome numbers. We hope to gain insight into the evolution of the polyploid karyotypes and to determine how the polyploids were produced.*

Polyploidy.

*Polyploidy has been reported to occur in the streptoneuran families Hydrobiidae and Thiaridae. Sanderson (1940, Proc. zool. Soc. London, 1939/40 (A): 109-110), in studying the chromosomes of the parthenogenetic *Potamopyrgus jenkinsi* from Scotland, found that there was only one non-reductional maturation division in the egg, and that the diploid number of chromosomes appeared to be $n=36$ in some cells and $n=44$ in others. Since Rhein (1935, Naturwissenschaften, 23 (6): 100) reported the continental race of *P. jenkinsi* to have 20-22 pairs of chromosomes, Sanderson concluded that the*

¹ Supported (in part) by N. I. H. Training Grant No. 5 T1 AI 41 from the National Institute of Allergy and Infectious Diseases, U. S. Public Health Service.

British snails are a tetraploid race which developed from their continental diploid relatives.

Melanoides tuberculatus, a member of the *Thiaridae*, is apparently also a polyploid species, or at least it contains polyploid populations. Jacob (1959, *Cytologia*, 24 (4): 487-497) found 16 pairs of chromosomes in one so-called race and $2n=90-94$ in another race, which he considered polyploid. However, it seems possible that two different species were involved. Jacob considered the polyploid race to be an autoallopolyploid arising from a cross between an autotetraploid parthenogenetic female of one species and a diploid male of another species. *M. lineatus* and *M. scabra* were also thought by Jacob to be polyploid. Another melaniid snail, *Balanocochlis* sp., is also presumably a polyploid, judging from its high chromosome number of $n=60$ (Burch, 1967, *Venus*, 25 (3/4): 118-135).

Among the *Euthyneura*, polyploidy has been reported in the families *Ellobiidae* (one isolated individual), *Ancylidae* and *Planorbidae*. Species of the freshwater limpet family *Ancylidae* have chromosome numbers of $n=15$, $n=17$, $n=18$, $n=30$ and $n=60$ (Burch, 1967, op. cit.). *Rhodacmea cahawbensis* has the chromosome number $n=15$, while two species each of *Ancylus* and *Ferrissia* have chromosome numbers that are multiples of 15. That there is a polyploid series with no known intermediate haploid numbers in the subfamily *Ancylinae* strengthens the contention that $n=30$ for *Ferrissia* (*Ferrissinae*) is also a polyploid (tetraploid) condition.

Burch and his colleagues have also studied polyploidy in the *Planorbidae*. In the subfamily *Planorbinae*, *Gyraulus circumstriatus* has 18 pairs of chromosomes and the closely related *G. parvus* has 36 pairs (1960, *Nature* 186: 497-498; 1965, *Malacologia*, 2 (2): 251). The greatest number of polyploid species yet studied are members of the planorbid subgenus *Bulinus* s. s. Nearly 50% of the species studied cytologically are polyploids (Burch, 1960, *Z. Tropenmed. Parasit.*, 11: 449-452; 1964, *Malacologia*, 1 (3): 387-400; 1967, *Malacologia*, 5 (2): 127-135; 1967 *Eth. Med. J.*, 5 (4): 245-257; Burch & Lindsay, 1970, *Malacol. Rev.*, 3 (1): 1-18). Most of the polyploid species are tetraploids, but hexaploid and octoploid species have also been found. Intermediate numbers produced by aneuploidy have not been discovered.

Chromosome morphology and behavior and other cytological phenomena.

Morphology of mollusk chromosomes and their characteristics during cell division do not differ from cytological conditions typically found in other animals. Chromosome number variation within individuals and populations, heterochromatic chromosomes, supernumerary chromosomes, bridges and fragments, univalents, trivalents and quadrivalents are among the cytological phenomena that have been observed in molluscan representatives. Karyotypes based on chromosome morphology have been presented for about 35 species. The karyotype, although potentially useful in cytogenetics of mollusks, has been used mainly in species discrimination. The most thorough comparative karyotype analysis of a snail group is that of Burch (1967, *J. Conchylol.*, 107 (1): 3-51) for species of the Japanese pleurocerid genus *Semisulcospira*. Chromosome numbers of species in this genus range from $n=7$ to $n=20$, with most species having a distinctive karyotype.

Sex chromosomes.

Sex chromosomes have been reported for several streptoneuran snails. Patterson (1965, *Malacologia*, 2 (2): 259-265) studied sex chromosomes in both male and female individuals of the viviparid species *Tulotoma angulata*, whose sex chromosomes are XX in the female with a dimorphic XY pair of sex chromosomes in the male.

Supernumerary chromosomes.

The most thorough study of supernumerary chromosomes of a mollusk is that of Evans (1960, *Heredity*, 15: 129-138), where the occurrence of supernumerary chromosomes in wild populations of *Helix pomatia* were investigated. From one to six extra chromosomes were found in various cells. All of the extra chromosomes were similar in the two populations studied in that they were submedianly constricted and smaller than chromosomes of the basic complement. Evans felt that the supernumerary chromosomes may have arisen from chromosome change occurring after a period of genotype instability due to inbreeding of these normally cross-fertilizing hermaphrodites.

OYSTER GENETICS AND THE PROBABLE FUTURE ROLE OF GENETICS IN AQUACULTURE

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ABSTRACT

Techniques for artificial rearing of commercial edible oysters have already been worked out. The oyster is generally regarded as a prime candidate for intensive aquaculture. Yet to be achieved is the true domestication of the oyster with the development of a variety of different strains so well suited to the methods of intensive culture in hatcheries that a margin of profit is reasonably assured to the commercial breeder. Domestication along with some genetic interference with the course of wild populations could further assure that this pelecypod mollusk contributes to the world food supply to the limit of its not-insignificant potential. Such "domestication" can be achieved by the deliberate application of genetic methods or, over a longer period, by trial and error breeding. Most likely, it will be accomplished through the combined efforts of researchers and commercial producers, the developments of one opening new avenues of approach to the other. This paper tells what is known already about the genetics of the oyster, reviewing such information in light of its significance in the application of different breeding programs to oysters, and to the introduction on natural beds of specially bred new oyster stocks to old wild populations. The review first presents background information on the cytogenetics of oysters, then goes on to consider them in the perspective of inbreeding, selective breeding, intra- and inter-species hybridization, and finally in respect to use in the future of induced mutations in special breeding programs.

DEVELOPMENT OF HYBRIDS BETWEEN *NASSARIUS* SPECIES FOLLOWING EXPERIMENTAL FERTILIZATION

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ABSTRACT

Sperm dissected from the testis or vas deferens and eggs dissected from either the oviduct or from capsules formed by isolated unfertilized females of *Ilyanassa obsoleta*, *Nassarius trivittatus*, *N. vibex*, *N. fossatus* and *N. cinisculus* have been used for hybridization studies. Sperm were collected by pipette and diluted two times with pasteurized sea water containing 50 mg/l of sulfadiazine and 50 mg/l streptomycin in abiotic sea water. Eggs washed three times in 15 ml of abiotic sea water were fertilized with 10-15 drops of sperm suspension. The cultures were gently shaken to mix sperm and eggs, allowed to sit ten minutes, after which the eggs were transferred to fresh abiotic sea water. Controls included isolated unfertilized eggs and eggs fertilized by sperm of the same species. The latter group included at least 75% normal development of embryos or else the experiments were discarded. Sperm from all of the above species were utilized, but eggs in satisfactory condition were not obtained from all of the species. Activation of eggs by non-specific sperm was approximately that of fertilized controls. First and second polar bodies were formed as well as the third polar lobe. Arrest often occurred at first cleavage. Dispermic eggs had a tripolar cleavage and were arrested shortly thereafter. Greater polyspermy involved either 1st cleavage or earlier arrest, regardless of whether or not the sperm nuclei underwent migration. Thus far, no hybrid embryos have proceeded beyond the trochophore equivalent, which has completed gastrulation and developed cilia. No later organogenesis has been observed. Additional experiments are currently underway.

ONCOMELANIA HUPENSIS (GASTROPODA: HYDROBIIDAE):
HYBRIDIZATION, GENETICS AND TRANSMISSION OF SCHISTOSOMA JAPONICUM

George M. Davis *

ABSTRACT

A model is presented for studying the intraspecific molluscan genetic mechanism(s) governing the transmission of the Oriental human blood fluke, *Schistosoma japonicum*. The Japanese strain of parasite was used. Male, parasite resistant, smooth, small, albino *Oncomelania hupensis formosana* from southern Taiwan were mated with female, susceptible, ribbed, large, pigmented *O. h. hupensis* from mainland China.

F_1 and F_2 generations were produced. Production of F_1 cross snails was significantly lower than that of the control inbred subspecies; however, this was due to females not being fertilized, not to lower output of young per female per month. Fecundity of $F_1 \times F_1$ crosses was equal to or greater than that of the control inbred subspecies.

The F_1 generation was equal in size to parental *O. h. hupensis*, was pigmented and with gradation in strength of ribbing, suggesting multiple allelic control of the last trait. The F_2 generation exhibited a 9:3:3:1 ratio of pigmented-ribbed:pigmented-smooth:albino-ribbed:albino-smooth. The F_1 generation and all classes of F_2 generation were susceptible to infection at the same level as parental *O. h. hupensis*, i.e., 1.6 ± 0.4 percent. Genes governing susceptibility are on a chromosome other than that controlling albinism or ribbing.

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GENETICS OF *BIOMPHALARIA GLABRATA* (GASTROPODA: PLANORBIDAE)

Charles S. Richards *

ABSTRACT

The genetic aspects of susceptibility of *Biomphalaria glabrata* for infection with *Schistosoma mansoni* have been studied. *B. glabrata* is hermaphroditic and isolated snails can reproduce by self-fertilization. Generation time is about six weeks, enabling us to follow eight consecutive generations in a year.

When two *B. glabrata* are mated, reciprocal cross-fertilization occurs. Pigmentation serves as a genetic marker in crosses. Basic pigmentation is a single gene character, following simple Mendelian inheritance. Three alleles of the gene occur resulting in six possible genotypes expressed as three pigment phenotypes. Wild type black pigmentation is dominant, albino recessive, while "blackeye" is recessive to wild type but dominant over albino.

The capacity of *B. glabrata* for both self- and cross-fertilization, short generation time, a long reproductive span of about a year, and pigment alleles enable selfing an albino and then mating it four or more times, alternating wild type and blackeye mates. The wild type and blackeye mates can then be used as males in serial crosses with other albinos.

Five single gene characters have been demonstrated in *B. glabrata*, representing five of the 18 linkage groups: (1) basic pigmentation, (2) pearl formation, (3) antler tentacles, (4) everted preputium and swollen tentacles, and (5) adult insusceptibility to *S. mansoni*.

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SOME SPECIES AFFINITIES IN THE OYSTER GENUS *CRASSOSTREA*

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ABSTRACT

Twelve species of Crassostrea from various areas of the world were available for study, including the local C. virginica and all the other principal commercial species. Seventy-two reciprocal crossing attempts were made of the possible 132 combinations. All crossing attempts were duplicated (as many as 12 times in some combinations), making a total of 282 attempts, and attempts made to rear 98 of these. Seven of the species were completely infertile with all other species, or showed less than 5% fertilization. Cross fertilization (cell cleavage and embryo development) occurred in crosses involving five species. Rearing hybrid embryos through to metamorphosis and attachment was successful with four species (C. angulata, C. gigas, C. rhizophorae, C. virginica). Although the fifth species (C. iredalei) had reciprocal fertilization with the other four, cytological examination showed chromosome anomalies and the embryos never lived beyond five days.

The above observations showed that five species of Crassostrea have close genetic affinities, but C. iredalei is more distantly related to the other four than they are to each other. Judging from ease of crossing, rearing larvae through metamorphosis, chromosomal behavior and morphological similarity, the closest relationships are between (1) C. angulata and C. gigas and (2) C. virginica and C. rhizophorae. It is concluded tentatively that C. angulata is a subspecies of C. gigas and that C. rhizophorae is a subspecies of C. virginica.

¹Initial work supported by NSF Grant 5034 and hybridization work continued through a Sea Grant (NOAA) to State University System of Florida.

CROSS-BREEDING EXPERIMENTS WITH THE AFRICAN SNAIL GENUS *BULINUS* (GASTROPODA: PLANORBIDAE)¹

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ABSTRACT

A totally albino strain (i. e., lacking even eye-pigment) of *Bulinus tropicus* (n=18) from Onderstepoort, Transvaal, South Africa was crossed with pigmented snails of each of the following seven populations: *B. tropicus* (n=18) from Malelane, Transvaal, South Africa; *B. natalensis* (n=18) from Lake Sibayi, Natal, South Africa; *B. tropicus* (n=18) from Lake Baharshangi, Ethiopia; *B. truncatus* (n=36) from Behaira Province, Egypt; *B. sericinus* (n=36) from Toquor River, Ethiopia; *B. hexaploidus* (n=54) from Sulultu River, Ethiopia; *B. octoploidus* (n=72) from Sheno, Ethiopia.

In two breeding experiments between the albino *Bulinus tropicus* (n=18) and the pigmented *B. tropicus* (n=18, Transvaal), both albino and pigmented parents produced only eye-pigmented F₁ progeny. The eye-pigmented and albino characters segregated in the expected 3:1 ratio in the F₂ progeny produced by mating F₁ siblings, and in the expected 1:1 ratio when F₁ individuals were backcrossed with albino snails. This indicates that the eye-pigment character is inherited in a simple Mendelian fashion in these populations of *Bulinus*.

In three breeding experiments between the albino *Bulinus tropicus* (n=18) and pigmented *B. natalensis* (n=18, Natal), the three albino parents produced only pigmented F₁ progeny, demonstrating successful cross-fertilization and dominance of eye-pigment. However, the three eye-pigmented parents failed to produce progeny. Here the genetic exchange was in only one direction: from pigmented to albino snails. Observation of the F₂ progeny obtained by sibling mating of F₁ snails showed that the eye-pigmented character segregated in the expected 3:1 ratio.

In four breeding experiments between the albino *Bulinus tropicus* (n=18) and pigmented *Bulinus tropicus* (n=18, Ethiopia), only two albinos produced pigmented F₁ progeny, and these with 25% and 28% embryo mortality. None of the pigmented parents produced eggs. The direction of genetic exchange was in only one direction: eye-pigmented to albino snails.

In the above breeding experiments between diploid populations, genetic exchange decreased as geographical separation increased.

In four breeding experiments between the albino *Bulinus tropicus* (n=18) and the pigmented *B. truncatus* (n=36, Egypt), neither albino nor pigmented snails produced progeny. In three breeding experiments between the albino *B. tropicus* (n=18) and the pigmented *B. sericinus* (n=36, Ethiopia), only one pigmented snail produced F₁ progeny: 19 eye-pigmented snails. Sibling mating of F₁ progeny produced no F₂ progeny. However, backcrosses of F₁ progeny to the albino diploid (n=18) snails immediately produced eggs, but with 100% mortality. This indicates that the F₁ progeny were sterile when mated to siblings, but they could at least produce non-developing eggs when backcrossed to albinos.

In four breeding experiments between the albino *Bulinus tropicus* (n=18) and the

¹Supported (in part) by a research grant (AI-07279) from the National Institute of Allergy and Infectious Diseases, U. S. Public Health Service, and (in part) by grants from the National Science Foundation, GB-13104 and GB-25986, to Dr. N. G. Hairston, The University of Michigan, for research in Systematic and Evolutionary Biology.

pigmented *B. hexaploidus* ($n=54$), all four pigmented snails produced vigorous pigmented F_1 progeny. However, no F_2 progeny were obtained from the sibling mating of F_1 progeny. In chromosome squash preparations of ovotestes from adult F_1 snails, incomplete meiotic divisions and lack of sperm were observed. None of the albino snails produced eggs. The direction of genetic exchange in these crosses was in only one direction: albino to pigmented snails.

In four breeding experiments between the albino *Bulinus tropicus* ($n=18$) and the pigmented *B. octoploidus* ($n=72$), only one pigmented snail succeeded in producing F_1 progeny, which were sterile. A histological study of ovotestes of adult F_1 progeny showed an extremely low number of ova and a lack of sperm. The direction of genetic exchange was again in only one direction: albino to pigmented snails.

WESTERN ATLANTIC *ERVILIA* (PELECYPODA: MESODESMATIDAE):
ASPECTS OF SYSTEMATICS, DISTRIBUTION, BIOLOGY, AND BEHAVIOR

John D. Davis *

Three species of *Ervilia* are found in the western Atlantic: *E. nitens* (Montagu, 1808), *E. concentrica* (Holmes, 1860), and *E. subcancellata* Smith, 1885. *Ervilia maculosa* Dall, 1896 (described from small specimens) is a synonym of *E. concentrica*. *Ervilia rostratula* Rehder, 1943 (described from larger specimens) is a synonym of *E. subcancellata* (described from smaller specimens).

E. nitens ranges from southern Florida and the Bahamas through the Caribbean to northern Brazil (Rio Grande do Norte). *E. concentrica* is concentrated along the southeastern United States coast from Cape Hatteras to Pensacola, Florida, with occasional appearances in the northern West Indies. *E. subcancellata* extends from Bermuda south to Florida and the Caribbean and along the Atlantic coast of South America to Sao Paulo, Brazil.

Living specimens of *Ervilia subcancellata* were collected in Bermuda in 1966 and studied at the Bermuda Biological Station. In Bermuda, *E. subcancellata* is found in intertidal and subtidal areas where there is relatively fine substratum usually in large part consisting of coral fragments and broken shell. Larger rocks or coral fragments are often present, and *E. subcancellata* may possibly tend to concentrate adjacent to these larger objects for additional cover and protection.

The foot was slender and very active, and was often extended for as much as 1.5 times the length of the shell. The ventral margin of the foot had a well-defined groove. Presumably, this groove secretes the mucous strands for attachment to substratum particles. Additional attachment in the substratum may possibly be provided by the many papillae which extend outward from the mantle margin.

The dorso-posterior excurrent siphon is the longer of the two siphons and has no papillae surrounding the distal opening. The more ventral incurrent siphon is equipped with a number of long papillae. During normal pumping/feeding activity these papillae curve inward over the siphon opening, presumably preventing entry of suspended particles or organisms.

Stomach contents were not examined, but considering the orientation of *E. subcancellata* in the substratum during these laboratory studies, I assume this pelecypod to be a filter feeder.

A specimen placed in a dish of seawater with suitable substratum would remain completely still for some time but eventually the siphons appeared and, shortly after, the foot protruded. At first the foot felt out the substratum, then was inserted between nearby sand particles. Subsequently the clam quickly pulled itself erect, several convulsive tugs drawing it part way into the substratum. After a pause of from several seconds to several minutes, 3-4 stronger tugs pulled the clam virtually out of sight, only the siphons remaining visible.

When preparing to dig in, the clam forced out a jet of water between the dorsal edge of the foot and the anterior adductor muscle, concurrently effecting a quick closing of the valves. The valves reopened almost immediately. The sudden water current usually forced some of the finer material away from the burrowing site. This observed burrowing pattern of *E. subcancellata* seems quite similar to the sequence attributed to the freshwater clam *Margaritifera margaritifera* by Trueman (1968) and later generalized for burrowing bivalves by Stanley (1970). Particularly interesting is the appearance of water currents from the mantle margin during adduction of the valves. As noted for *E. subcancellata*, this sudden flow of water removes finer sediment particles from the burrowing area. In *M. margaritifera*, according to Trueman, valve adduction (closing) is rapid and corresponds with expansion (dilation) of the foot and forced expulsion of water from the mantle cavity. Concurrently, the siphons are closed. The burrowing behavior pattern and sequence of events of *Ervilia subcancellata* appears to be closely similar. It is altogether possible that valve adduction, foot expansion and expulsion of mantle cavity water are behavioral patterns commonly held by most pelecypod mollusks burrowing in relatively coarse, loose substratum.

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THE SYSTEMATIC POSITION OF *RADIX LUTEOLA* AND ITS
SIGNIFICANCE IN LYMNAEID SYSTEMATICS¹

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ABSTRACT

Taxonomy of the freshwater basommatophoran family Lymnaeidae has received much attention in the past. Nevertheless, systematic relationships of taxa within the family are still open to debate. Some authors would lump all the Recent species into a single genus (Lymnaea), or at most two genera (Lymnaea and Lanx), while others recognize several genera (e. g., Lymnaea s.s., Acella, Austropeplea, Bulimnea, Fossaria (=Galba), Lanx, Pseudosuccinea, Radix, Stagnicola, etc.). These latter genera were all separated originally on shell characters, a taxonomic practice criticized by some recent malacologists. Burch, Lindsay & LoVerde (1971, Zool. Zh., 50 (8): 1158-1168) showed that in three species of Lymnaeidae (one from North America, one from Poland, and the other species common to both regions), shell characters are better indicators of systematic relationships than characters of the reproductive system (as previously used).

Walter (1968, Amer. malacol. Union, ann. Repts., 35: 18-19, 23-25; 1969, Malacol. Rev., 2: 1-102) has assigned considerable importance to the multifolded condition of the lower "prostate" gland of the lymnaeid male reproductive system. Most lymnaeids have a unfolded lower prostate (Roszkowski, 1926, Ann. Zool. Mus. Polonici Hist. natur., 5 (1): 1-14, and subsequent publications; Hubendick, 1951, Kungl. svenska Vet.-akad. Handl., ser. 4, 3 (1): 1-223), but in a few species it is unfolded, and in three species it is known to be multifolded (the Holarctic Lymnaea stagnalis, the Polish Stagnicola corvus and the Indian Radix luteola). If the folded condition of the lower "prostate" gland is of prime importance in indicating systematic relationships in the Lymnaeidae, then one would assume that the latter three species are rather closely related, in spite of their conchological differences. However, cytological and electrophoretic data (Burch & Lindsay, 1969, Malacol. Rev., 2: 135), as well as immunological studies (Burch, Lindsay & LoVerde, op. cit; Burch & LoVerde, present report), do not support such conclusions. L. stagnalis and S. corvus are not closely related, R. luteola is not closely related to either of these two species, but it is closely related to all other species of Radix that we have been able to compare. Thus, R. luteola is yet another species demonstrating that characters of the reproductive anatomy are to be used with caution in assessing systematic relationships within the Lymnaeidae.

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¹Supported by research grants from the National Institute of Allergy and Infectious Diseases, U. S. Public Health Service (N. I. H. Training Grant No. 5 T1 AI 60), the National Science Foundation (grant GB-7569), and the Foreign Currency Program, Office of International Activities, Smithsonian Institution.

AGGREGATIVE BEHAVIOR IN VERONICELLID SLUGS: A PRELIMINARY REPORT

Dee S. Dundee *

ABSTRACT

A continuing series of experiments with veronicellid slugs has demonstrated aggregative behavior which appears to be the result of a pheromone (s).

Veronicella ameghini and *V. floridana* are being studied at present and an attempt to determine the chemical nature of the pheromone will be undertaken soon.

This finding is significant since little is known about molluscan pheromones. If such pheromones could be isolated from these and/or other molluscs, various possibilities would present themselves: for example, as attractants for undesirable molluscs.

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SCANNING ELECTRON MICROSCOPE STUDIES OF LAND SNAIL RADULAE

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ABSTRACT

With a useful magnification range from 14x to more than 50,000x combined with 500x the depth of field available with optical equipment, the scanning electron microscope is becoming the routine instrument for use in examining radular structure and function. The same radular tooth can be studied at a variety of magnifications and from many different angles, enabling three-dimensional viewing and understanding of structure. By modeling the radula into a simulated feeding stroke, the teeth position in both functioning and relaxed stages can be observed from the same preparation.

Carnivorous land snails have evolved in several different lineages. All agree in having a reduced number of teeth with elongated single cusps. When the teeth are elevated for slicing into their prey, great stress can be generated and transmitted to the tooth base. Modifications of the anterior tooth margin to provide support during the stress period of resistance to cutting differ from family to family. In the *Oleacinidae* the anterior tooth margin is abruptly truncated; in some *Haplotrematidae* there is anterior elongation of the tooth base; in some *Systrophidae* the modification is for folding; while in the *Paryphantidae* the teeth slice at a much lower angle.

Most herbivorous families have a complex inter-row support system that functions to convert resistance pressure encountered by one tooth into assistance for the tooth in the next row. Examples from the *Enidae*, *Partulidae*, and *Camaenidae* demonstrate the diversity of such support systems. Details of such inter-row support can vary widely between closely related genera, or can be completely absent. Lack of similarity between two sympatric Australian desert *Camaenidae* and the lack of any support structure in *Papuina* from the Bismarck Archipelago suggest that this feature has no value in working out higher classifications.

Several land snails have the teeth modified to form spade-like scraping cusps. Examples from the *Enidae* and *Partulidae* are used to show how an extremely similar structure can be derived independently.

Other uses of the scanning electron microscope in studying pulmonate radulae will include examination of wear patterns, growth rates, and the form and ontogeny of individual teeth. These attributes will be of value in systematic revisions.

Grateful acknowledgment is made to the American Philosophical Society for support of the studies on carnivorous species.

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SALTATIONAL SPECIATION IN AMERICAN HELMINTHOGLYPTIDAE
(GASTROPODA: PULMONATA)

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The Helminthoglyptidae is a large family of New World land snails ranging from British Columbia to Patagonia. It appears to be most closely related to the Bradybaenidae in Asia. The fossil record shows it to be in North America during Eocene and possibly as early as late Cretaceous. In the southwestern United States and adjacent Mexico, there are 12 described and at least three undescribed genera. Determination of phylogeny among these genera is a complex task involving the comparison of shell morphology, anatomy, chromosome karyotype, and body proteins, together with due regard for present and past zoogeographical considerations.

The family Helminthoglyptidae is characterized as "dart-bearing helices", but many of its genera have no dart apparatus. In such cases, it is generally agreed that dart-less forms have become secondarily simplified from a dart-bearing ancestor. The genera *Sonorella*, *Sonorelix*, *Mohavelix*, *Greggelix*, and *Tryonigens* are dart-less, while *Helminthoglypta*, *Eremarionta*, *Xerarionta*, *Plesarionta*, and *Micarionta* are dart-bearing. It is tempting to hypothesize that all dart-less genera form a monophyletic subfamily evolved from one dart-less ancestor by way of adaptive radiation. For example, *Sonorelix* could have evolved from an *Eremarionta*-like ancestor by losing the dart apparatus; in turn, it could have given rise to *Sonorella* and *Greggelix* and subsequently, *Sonorella* could have given rise to *Mohavelix* and *Tryonigens*. Evidence

tends to indicate that the monophyletic concept of a dart-less subfamily is incorrect. The first such bit of evidence was in the discovery of a new species of *Helminthoglypta*, *H. micrometalleoides* W. B. Miller, 1970, in very close proximity to *Mohavelix micrometalleus* (Berry, 1930) in the arid El Paso Mts. of the Mojave Desert. Shell morphology and zoogeography favor the hypothesis that *Mohavelix* arose saltationally from *H. micrometalleoides* rather than from a distant *Sonorella* ancestor. New evidence has been uncovered in the *Eremarionta argus* (Edson, 1912) complex of the Mojave Desert. Shells of a new, undescribed genus are indistinguishable from *Eremarionta* shells but the anatomy shows it to be dart-less and very simplified. Again, shell morphology and zoogeography strongly point to a saltational speciation phenomenon. Other instances of probable saltational speciation are being discovered in still other helminthoglyptid genera but have not been documented sufficiently to discuss at this time.

Saltational speciation is an extreme case of rapid genetic drift and is probably brought about by major chromosomal breakage and rearrangement in isolated, desert populations decimated by severe climatic stress. Studies are presently underway at the University of Arizona to compare karyotype and protein patterns in the various genera of western helminthoglyptids in an effort to find additional evidence to assist in elucidating their phylogeny.

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THE FAMILIES OF THE PEARLY FRESHWATER MUSSELS

Joseph P. E. Morrison*

Brooks, in 1875, reporting on North American "*Unio*" (actually Amblemidæ), may have been the first to indicate the true story of the development and relationships of the pearly freshwater mussels. He reported that the shell nucleus develops first as an undivided, saddle-shaped structure on the middle of the slightly elongate embryo. This stage corresponds to the lasidium and the haustorium larva of the Mycetopodidae and the Mutelidae. In other words this first stage corresponds to the Mutelacea. Because the embryonic shell is later divided into two distinct valves, the glochidium larva of the Unionacea is considered more advanced. I consider the Unionacea more advanced than the Mutelacea.

The Mutelacea possess the lasidium type of larvae, with the strong development of anterior pallial processes of the mantle, which are in effect attachment processes that grow into the host tissues in a mucus blister on the surface of the host fish. When these larvae are completely mature, they break off their attachment stalks and leave the fish hosts to begin their adult lives. This Superfamily contains the families Mutelidae, Etheriidae, Mycetopodidae and Acostaëidae.

The Family MUTELIDAE, whose haustoria larvae are incubated in the inner gills only, are African. *Spatha*, *Mutela*, and a few other genera belong here.

The Family ETHERIIDAE (the "freshwater oysters" of the larger African Rivers) are distinct because they are cemented to rocks, or other shells in rapid water. Characteristically they show blistered, greenish nacre. In spite of being attached, they have retained both anterior and posterior adductor muscles. The occurrence of eggs in the inner gills of the females of the *Etheria* mussels indicates their relationship with, and derivation from, the unattached mutelid mussels of the same region.

The Family MYCETOPODIDAE of South America, are gravid in the inner gills only, with the lasidia larvae described first by Von Ihering. These lasidia larvae also attach in a mucus "blister" to the skin of the fishes, then when mature, break off the attachment stalk to start juvenile adult life. One genus, *Anodontites*, is living as far northward as Vera Cruz, Mexico. *Bartlettia* mussels are only modified *Anodontites* hooked into firm (rocky?) bottoms, but are not cemented on. Most of the Mycetopodidae possess markedly greenish nacre.

Another Family, the ACOSTAEIDAE, living in the Magdalena River System, are the "South American freshwater oysters". The shells of *Acostaea* are cemented to rocky bottoms, but unlike the "African freshwater oysters", they are modified in the adult to retain only one (the posterior) adductor muscle. Their unblistered greenish colored nacre is so obviously similar to the nacre of the Mycetopodidae from the same region, that I consider them most closely related.

The Unionacea reproduce by means of glochidia larvae, distinctly bivalved from the later embryonic stages onward. With many other characters involved, there is more apparent divergence and/or convergence in this complex of Families. They may have developed from more than one original ancestral stock. This Superfamily contains the Families Margaritiferidae, Hyriidae, Unionidae, Amblemidæ and Pseudomulleriidae.

The MARGARITIFERIDAE stand alone, not directly in the ancestral line of any other Family. They have retained the most primitive gill structures, with diagonal, incomplete gill septa, and incomplete separation of the siphonal openings. Their very small glochidia, borne in all four gills, are parasitic on the gills of fishes. The very few species are relict, with one species circumpolar, and a very few others southward in southeast Asia, and southeast North America. The only two highly sculptured members of this Family are known from North Vietnam, West of Canton, China, in the Pearl River System, and from the southern United States (southern Alabama and Louisiana).

The HYRIIDAE carry their lop-sided, subtriangular, hooked glochidia in the inner gills only. In South America, *Tetraplodon* (*Hyria*) and other genera including the widespread *Diplodon* have been studied extensively by Bonetto and other authors. The glochidia larvae of the hyriid mussels are normally parasitic on the external surfaces (fins, tail, etc.) of their host fishes. Bonetto has indicated that some species of *Diplodon* may have secondarily dropped the parasitic stage on fishes and metamorphose directly. With identical characters by definition, this Family must also include the genera and species of the Australian Region often called the Hyridellidae, etc.. It seems there are two Austral Regions, populated by surviving members of the Hyriidae, while mussels we consider more highly specialized moved in behind them, both in Asia and in America.

The Family UNIONIDAE includes mussels that

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reproduce by means of triangular, hooked glochidia carried only in the outer gills of the gravid females. These glochidia are normally shed in strings of mucus trailing along the bottom. Chance contact by fish of an appropriate species results in the glochidia being clamped (hooked) onto the fin or tail edge, followed by encystment, and successful parasitism and metamorphosis to the juvenile mussel. The typical genus *Unio* is living from Europe eastward across Asia to China. Other relatives are known from Asia. On the other hand this Family is represented in North American waters only by members of the Subfamily Anodontinae. These North American mussels, as well as all other Anodontinae differ from the typical Unioninae by the partial reduction of, or the complete loss of, the hinge teeth.

The AMBLEMIDAE, the most highly specialized free-living Unionacea, produce hookless glochidia, usually of elongate shape, with short hinge lines. Their glochidia are normally parasitic on the gills of fishes. Some are gravid (carry the glochidia) in all four gills; some in the full length of the outer gills; the most highly specialized in only a part of the outer gills. With one exception, members of the typical Subfamily Amblesinae do not show any sexual dimorphism of the shells. In Africa, Asia, and America, genera of the Amblesinae include some of the smallest and thinnest, as well as the largest and thickest-shelled pearly freshwater mussels known.

The more specialized subfamily Lampsilinae shows permanent modification of the marsupial portions of the outer gills, and a corresponding permanent modification of the shells of the females, resulting in sexual dimorphism of the adult shells.

The necessity of parasitism on the gills of the host fish species has led to a variety of "bait - mechanisms" that serve to induce fish to "mouth" the glochidia, and so enable the glochidia to reach the gill filaments, to be there encysted and undergo their larval metamorphosis. In United States waters, the crimson glochidia of *Fusconaia* species, and the white glochidia of *Pleurobema* and other related genera may be shed in packages (conglutinates) resembling pink or white (flat) worms lying on the bottom. *Cyprogenia* has been recorded as shedding the conglutinates entire; resembling coiled red worms, which are avidly

"eaten" by fish. *Ptychobranchus* ejects entire conglutinates which resemble in size, shape, and color, newly hatched fish embryos. A "tasty" morsel to attract predator fish species.

The mantle margins ventral to the siphons, of some of the Lampsilinae of North America, show "fish - bait" structures. The genus *Toxolasma* has small caruncles, which move like "twiddling thumbs" and attract small and/or young fish to eat the "wriggling red worms". *Ligumia* and *Villosa* have papillae that resemble worms of various types. The mantle margins of *Villosa amygdala* from southern Florida possess varicolored brown and green papillae that together resemble a caterpillar that has fallen into the water and is lying on the bottom.

The extreme "fish - bait" structure and mechanism is shown by *Lampsilis* species. The females have an eye-spotted, minnow-like mantle flap below the siphons. These specially innervated flaps move and resemble the intermittent jerking of a wounded minnow. This occurs when the glochidia are ripe in the late spring and the females are "up-ended" in the bottom, thereby fully showing this action. The host fish gets a mouthful of glochidia (burst out of the edge of the marsupia) when it attempts to eat the "wounded minnow".

Another extreme is shown by the blue or white "flags" of certain *Plagiola* species, which may be visible seven metres away in the clear water over the shallows, in their glochidia shedding season. *Plagiola rangiana* Lea was known to local fisherman as the "White Mouth" when it was described 133 years ago.

The Family PSEUDOMULLERIDAE is the third "freshwater oyster" family in the world. *Pseudomulleria* is living in certain rivers of southern India. The juvenile mussel starts as a small bilaterally symmetrical bivalve, then is attached, and changes to retain only one adductor muscle between the asymmetrical attached and free valves of the adult mussel. The general appearance, especially of the nacre of *Pseudomulleria*, is so different from the green nacre of *Acostaea* of South America that they should not be considered members of the same Family. Only examination of the marsupial gills and of the glochidia of *Pseudomulleria* can prove from which other Family of the Unionacea they have been modified.

AMU COMMITTEE AND BUSINESS REPORTS

REPORT OF CONSERVATION COMMITTEE

The Conservation Committee meeting, attended by approximately 16 persons, opened with a discussion of the response of member shell clubs to a questionnaire concerning their interest and participation in conservation problems, which was mailed out with the AMU Bulletin in April. Unfortunately the questionnaire did not reach the clubs until a deadline date for replying had expired and only about five clubs returned their forms.

From this meager response it appears there is very little conservation activity being carried out by shell clubs with the exception of the Sanibel Island Shell Club, which has a most active program in this field.

The responding clubs indicated that they would be interested in a bibliography of inexpensive educational material on conservation, ecology, etc. A chairman will be appointed who, with the help of other Conservation Committee members, will compile such a bibliography for distribution either through the AMU Bulletin or by direct mail.

It was agreed that the AMU as an organization has made little impression on most shell club members. If we are to influence shell collectors, we should dramatize our existence. The committee therefore recommended the AMU put themselves into the shell club world by offering two awards, as follows:

1. An award to an individual in the form of a 'noticeable' trophy, plaque, framed certificate or similar award to be given for the best exhibit in a shell club show which demonstrated some malacological feature of a species or group of species. It was emphasized that we should especially encourage exhibits using photographs, slides, movies, drawings, etc. of the living shell - preferably illustrating some ecological characteristics, a phase of life history, or some other biological approach, and perhaps not exhibiting the actual shell of the species involved at all.

2. An award to a shell club given on Shell Club Night at the Annual AMU Meeting for submitting a scrapbook as evidence that the club had completed some outstanding conservation project. The decision would be by committee, with a chairman receiving the scrapbooks to be judged prior to the meeting and making a 'digested' evaluation to help the committee select a winner.

It was requested that the President of AMU and the Conservation Chairman appoint an Awards Committee which would work out the necessary details of the two awards, such as who would be eligible, rules for entering, nature of the award, criteria for judging, etc. These rules would be submitted for the Council's approval at the 1973 meeting and should go into effect as soon as possible thereafter.

Because of the difficulty of thoroughly investigating all requests for help in either supporting or opposing legislation concerning conservation, the Conservation Committee requested that a broad policy statement of AMU's attitude on ecological matters be drafted for the Council's approval, permitting the use of this statement in lieu of more pointed support where such support is impossible because of lack of time, knowledge, etc. Carol Stein was appointed chairman of this project with the privilege of calling on any other AMU members whose support or advice she might need.

It was also suggested that a Creed of Collecting Ethics be drafted for Council's approval. This was also assigned to Miss Stein, and it was hoped that possibly these two statements of policy could be ready for publication in the AMU Bulletin for 1972. Council members would be polled for approval.

A resolution urging judges to disqualify shell show competitive exhibits utilizing specimens of any molluscan species listed on U. S. government lists of endangered species was passed by the Conservation Committee, the Council and by the membership at the annual business meeting. The resolution has been published in the 1972 Fall AMU Newsletter. At the moment use of only one species, *Papustyla pulcherrima* from Manus Island, is so restricted.

A resolution requesting AMU support for legislative measures protecting certain areas of the Driftless Area of Minnesota, Wisconsin, Iowa and Illinois was tabled because of the lack of time for investigation of all the ramifications involved. The problem is described in the paper by Marc J. Imlay, printed herein. Individuals were reminded they could support the resolution privately.

The sum of \$200.00 was allocated for the Conservation Committee in 1972-73.

Respectfully submitted, Anne B. Speers, AMU Conservation Committee Chairman.

REPORT OF AMU ANNUAL BUSINESS MEETING, JULY 13, 1972

President Arthur S. Merrill, presiding, called for a motion to waive reading of the minutes of the previous annual business meeting because they had been printed in the Bulletin for 1971. Motion made, seconded, carried.

The reports of the Recording Secretary, Corresponding Secretary and Treasurer for 1971 were heard and approved. They are printed on the following pages. A detailed budget was not submitted, but both income and expenditures were estimated at \$4,600 for fiscal 1973. It was noted that total 1971 expenditures were \$3,850 and the Council had authorized special budget items totalling \$600 in the coming year.

President Merrill asked the various committee chairmen to report, as they had in the Council meeting, on their activities during the year and on action by the Council. The membership thus got an unusually complete view of the number and variety of problems considered by the Council. Dr. Clench reported that the History and Archives Committee had found a place for the AMU Library - a room of our own at the Delaware Museum of Natural History. An allocation of \$400 has been made to buy used furniture for the room. Mr. Jacobson reported for the Publications Committee. He mentioned the new format for the annual report, now called the Bulletin. A fourth edition of *How to Collect Shells* will be prepared in the coming year. It will be titled "How to Collect and Study Shells", and although it will have similar articles, it will stress conservation more than past editions. Dr. Clarke reported for the Constitutional Revision and Legal Committees. A revision of the Constitution and By-Laws of the AMU is progressing, but a final draft is not yet ready for action by the membership. Article VIII, prohibiting lobbying, will be deleted. Article VIII of the By-Laws will be re-worded to clarify the disposition of excess funds from an Annual Meeting or payment of a deficit from general funds. Article III, Section 3 will be amended to avoid double payment of officers' travel expenses. AMU dues for institutions will be \$6 per year, starting with 1973. This includes colleges, libraries and government entities; it is intended to compensate for the extra time required to process these memberships.

Dr. Murray reported for the Membership Committee. He echoed the Recording Secretary's concern over decreasing membership, but said he could not determine any particular cause. The Council will

investigate the possibility of establishing a junior membership with lower dues for those under a certain age. A greater emphasis on publicity will be made in the coming year, especially in connection with the Annual Meeting. The following resolution, approved by the Council, was presented to and approved by the membership: "It has been brought to the attention of the Council that Mrs. Miriam Hicks has been answering, over a period of time, a number of inquiries from young people who addressed letters to the AMU care of the address of the former International League of Young Shell Collectors. The AMU wishes to express gratitude to Mrs. Hicks for her efforts in encouraging young shell collectors. The Council approves that she be authorized to forward any future mail to the Corresponding Secretary for reply, and be reimbursed for postage expense in connection with this."

Mrs. Speers reported for the Conservation Committee, and her report is printed in detail on Page 47.

Dr. Clench reported that the Annual Meeting in 1973 would be on the campus of the University of Delaware in Newark, Delaware. Our hosts will be the Delaware Museum of Natural History and the new Wilmington Shell Club. The dates are June 24 to June 29.

Dr. Morrison presented the following slate, prepared by the Nominating Committee: President, Dolores S. Dundee; President-Elect, Harold D. Murray; Vice President, John B. Burch; Treasurer, Mrs. Myra Taylor (3 years); Councillors-at-Large (2 years), Corinne Edwards and Dorothea Franzen; Publications Editor (5 years), Arthur H. Clarke. The other officers do not require election this year. It was moved, seconded and voted that the members accept the slate as presented, and that the Secretary cast a unanimous ballot. (Lt. Col. Edwards could not take office because she had not been a member for two years, as required under the By-Laws, Article IV, 2.) The new Treasurer will take office on January 1, 1973. Bunny Baker and Karl Jacobson, the outgoing Treasurer and Publications Editor, were commended for their years of service to the AMU.

The new members of the various committees were introduced.

Dr. Merrill turned the meeting over to the new President, Dr. Dundee. As there was no new business, Dr. Dundee adjourned the meeting.

Respectfully submitted, Marian S. Hubbard,
Recording Secretary.

REPORT OF THE CORRESPONDING SECRETARY FOR 1971

Since I took over the job of corresponding secretary in July and handled the backlog, letters have been coming into my mailbox at an average of five a week. Most of these can be answered by supplying the writer with one of the five pieces of duplicated material on hand, together with a form letter thanking the writer for his inquiry.

Some take a more specific form of answer. Some have been referred to specialists in the field, with the names taken from the AMU Bulletin. Others have been in Spanish, Italian and French. Fortunately I did study all three in college, together with German, so that I could figure out what information they were seeking.

I might say, Mrs. Marian S. Hubbard has offered invaluable aid when I've been stumped, as well as helping me get started.

Some letters have been challenging: the one from an engineer in India who sent a picture of a chalcidony volute (with a left-handed spiral) and wondered why specialists in this country couldn't tell him all about it. He was referred to Dr. Katherine Palmer.

There also was the little girl who asked what does the American Malacological Union do, and the youngster who said he was interested in malacology and please send him some.

Respectfully submitted, Paul R. Jennewein, Corresponding Secretary.

REPORT OF THE RECORDING SECRETARY FOR 1971

As of January 1, 1972, the membership of the AMU was 717, a net decrease of 119 individuals and an increase of 13 organizations. The following is a comparison, by category, with the two previous years:

	1/1/70	1/1/71	1/1/72
Individual*	506	510	451
Individuals under Family Membership (2 or more people per membership)	185	235	190
Honorary Life Members	8	9	8
Corresponding Members	28	37	23
Clubs and Regional Organizations	37	32	45
TOTAL	764	823	717
* Including Paid Life Members	18	18	18

The net loss of 106 is serious, but it conceals an even more serious statistic: 192 people, or almost 25% of those on the rolls at 1/1/71, were dropped during the year for non-payment of 1971 dues. I took it upon myself to write to the people I thought were really still interested in malacology, and I had good results with renewals. I continued writing as I had time, eventually sending 85 letters to 100 people in the United States and 14 letters abroad. To date over 30 of these people have renewed (June 1972). New people are joining at what appears to be a greater rate than in 1971, when the average was five per month. We would really like to know why so many people have dropped membership. We know that some have moved without leaving a forwarding address, and a few have written to give a reason for resigning, but most simply do not answer our letters.

From August 1970 to June 1971, the AMU had no

Corresponding Secretary. I answered as many of the general inquiries as possible during that period, and was much relieved when Paul Jennewein agreed to accept the position. This left me with more time to do things for which I had no time the previous year. I can now read the club publications and pass along pertinent information to Paul Jennewein. I can keep in closer touch with the clubs and officers of the AMU. I find that I still have a heavy load of correspondence. I sent out well over 700 pieces of mail in 1971, although I was acting as Corresponding Secretary for only the first five months.

I hope to continue to grow in knowledge of the job, and be better able to serve you in the coming year.

Respectfully submitted, Marian S. Hubbard, Recording Secretary.

REPORT OF THE TREASURER FOR THE FISCAL YEAR ENDING December 31, 1971.

Checkbook Balance, January 1, 1971 2060.22

Receipts:

Memberships:	Sustaining	50.00	
	Regular	2284.83	
	Corresponding	125.75	
	Shell Clubs	<u>313.50</u>	2774.08
Sales:	HTCS	329.98	
	Rare & End. Species	193.25	
	Back Issues - Bulletin	<u>75.15</u>	598.38
	Proceeds of Cocoa Beach Meeting		361.05
	Page Charge to Authors		552.00
	Interest on Bonds		166.14
	Miscellaneous	<u>6.71</u>	
	Total Receipts	4458.36	
Transferred from Savings Account		<u>700.00</u>	<u>5158.36</u>
Total Cash to be accounted for			<u>7218.58</u>

Disbursements:

Printing:	Annual Report	3051.01	
	Other Printing	<u>172.22</u>	3223.23
	Postage		262.75
	Bank Charges		22.30
	Sec's Expenses to Annual Meeting		286.15
	Miscellaneous Office Expenses	<u>49.50</u>	
	Total Operating Expenses		3843.93
	Transferred to Savings Account		<u>1500.00</u>
	Total Disbursements		5343.93
Checking Account Balance, Dec. 31, 1971			<u>1874.65</u>
Total cash accounted for			<u>7218.58</u>

Savings Account B14592, Colonial Federal Savings & Loan Asso.

Balance, January 1, 1971	1711.24	
Interest for the year	84.26	
Deposit from checking account	<u>1500.00</u>	3295.50
Withdrawal		<u>700.00</u>
Balance, January 1, 1972		2595.50

Recapitulation of Assets, December 31, 1971

Cash in Checking Account, Girard Trust	1874.65
Treasurer's Petty Cash	10.00
Secretary's Petty Cash - Marian Hubbard	100.00
Savings Account	2595.50
Savings Bonds - Girard Trust	<u>3000.00</u>
Total Assets	7580.15
Allocated to Life Membership Fund	<u>1470.88</u>
AMU Net Worth - December 31, 1971	<u>6109.27</u>
Changes in Capital Account:	
AMU Capital Account, January 1, 1971	5410.58
AMU Capital Account, December 31, 1971	<u>6109.27</u>
Net Increase in Assets, 1971	<u>698.69</u>

Respectfully submitted, Bernardine B. Baker, Treasurer

Audited January 17, 1972 by Virginia O. Maes and George M. Davis

THE AMERICAN MALACOLOGICAL UNION, INC.

ACTIVE MEMBERS

Membership List Revised October 20, 1972

Abbott, Dr. and Mrs. R. Tucker, Delaware Museum of Natural History, Greenville, Del. 19807
 Abel, Richard & Company, Inc., P. O. Box 4302, Portland, Ore. 97208
 Academy of Natural Sciences Library, 19th and the Parkway, Philadelphia, Pa. 19103
 Adey, Mrs. John S., Jr., Lee's Hill Rd., New Vernon, N. J. 07976 (General interest)
 Aguayo, Dr. Carlos G., College of Agriculture, Mayaguez, Puerto Rico 00709
 Albert, Mrs. Ernest, 905 Bayshore Blvd., Safety Harbor, Fla. 33572
 Alexander, Robert C., 423 Warwick Rd., Wynnewood, Pa. 19096
 Allen, Dr. J. Frances, 7507 23rd Ave., Hyattsville, Md. 20783
 Allen, James E., 1108 Southampton Dr., Alexandria, La. 71301 (Tertiary micro-mollusca)
 Allen, Mrs. Lawrence K., Box 822, Port Isabel, Texas 78578 (*Murex*, *Pecten*, world marines; dealer)
 Allen, Miss Letha S., 187 Argyle St., Yarmouth, Nova Scotia, Canada (General)
 Anders, Kirk W., Shells of the Seas Inc., P. O. Box 1418, Ft. Lauderdale, Fla. 33302 (Volutidae; all rare shells)
 Anderson, Carleton J., Kettle Creek Rd., Weston, Conn. 06880
 Andrews, Mrs. Jean (Wasson), 241 Melrose, Corpus Christi, Texas 78404
 Angstadt, Mrs. Earle K., Longview Farm, 959 Whitner Rd., Reading, Pa. 19605
 Aslakson, Capt. Carl I., 5707 Wilson Lane, Bethesda, Md. 20034
 Athearn, Herbert D., Rt. 5, Box 376, Cleveland, Tenn. 37311 (Freshwater)
 Athearn, Mrs. Roy C., 5105 N. Main St., Fall River, Mass. 02720 (Land shells)
 Auerbach, Stuart, 1710 Algonquin Trail, Maitland, Pa. 32751
 Avery, Mrs. R. Gail, Box 2557, Harbor, Ore. 97415 (Shells of West America; exch.)
 Baerreis, David A., 1233 Sweet Briar Rd., Madison, Wisc. 53705 (Paleoecological interpretation through mollusks)
 Baily, Dr. Joshua L., P. O. Box 1891, La Jolla, Cal. 92038
 Baker, Mrs. Horace B., 11 Chelton Rd., Havertown, Pa. 19083

Baker, John A., P. O. Box 4524, Patrick AFB, Fla. 32925 (General)
 Baker, Nelson W., 279 Sherwood Dr., Santa Barbara, Cal. 93105 (General)
 Baker, Wilma, Orange Acres, Lot 65, Sarasota, Fla.
 Barlow, Mrs. G. Barton, 5 Downey Dr., Tenaflly, N. J. 07670
 Barton, Mrs. James, 20 Newfield Dr., Rochester, N. Y. 14616 (*Cypraea*; worldwide general collection, especially Hawaiian)
 Bates, John M., Director, Center for Aquatic Biology, Eastern Michigan Univ., Ypsilanti, Mich. 48197
 Bauer, Mr. and Mrs. Hugo C., P. O. Box 894, League City, Texas 77573 (All Mollusca)
 Baum, Newman N., 83 Weaving Lane, Wantagh, L. I., N. Y. 11793
 Baxa, Mrs. Dorothy and Mr. Edward H., Box 177, Genesee Depot, Wisc. 53127 (Beginning coll.; gaining knowledge of mollusks)
 Bayne, Dr. and Mrs. C. J., Dept. of Zoology, Oregon State Univ., Corvallis, Ore. 97331 (Gastropod physiology)
 Bazata, Kenneth R., Univ. of Nebraska, Oldfather Hall 434, Lincoln, Neb. 68508 (Terrestrial pulmonates)
 Becker, Mr. and Mrs. Albert F., 2157 Sunrise Dr., LaCrosse, Wisc. 54602 (Mississippi River shells)
 Bedford, Mrs. Ann W., P. O. Box 6181, West Palm Beach, Fla. 33405
 Beetle, Mrs. Dorothy E., Peninsular Science Center, 524 J. Clyde Morris Blvd., Newport News, Va. 23601 (Land, freshwater world shells)
 Bennett, Mr. and Mrs. Charles G., 374 73rd St., Ocean, Marathon, Fla. 33050
 Bequaert, Dr. Joseph C., Dept. of Entomology, Univ. of Arizona, Tucson, Ariz. 85717
 Berry, Dr. and Mrs. Elmer G., 1336 Bird Rd., Ann Arbor, Mich. 48103
 Berry, Dr. S. Stillman, 1145 W. Highland Ave., Redlands, Cal. 92373
 Bickel, David, Dept. Earth Sci., Minot State College, Minot, N. Dak. 58701 (Systematics and ecology of freshwater mollusks, esp. pleurocerid snails)
 Bijur, Jerome M., 135 7th Ave. N., Naples, Fla. 33940 (Buy, exch. Florida and Caribbean marine)
 Bippus, Mr. and Mrs. Alvin C., 2743 Sagamore Rd., Toledo, Ohio 43606 (Marine gastropods)
 Blaine, Mr. and Mrs. Alger P., 237 19th Ave. S., St. Petersburg, Fla. 33705 (Summer: 74 Palmer Ave., Springfield, Mass. 01108)

- Blankenship, Shaw, Route 2, Crab Orchard, Ky. 40419 (Fresh water mussels)
- Bleakney, Dr. J. Sherman, Dept. of Biology, Acadia Univ., Wolfville, Nova Scotia, Canada (Nudibranchs and sacoglossans; ecology, zoogeography, systematics)
- Bledsoe, William D., 11763 Sunset Blvd., Los Angeles, Cal. 90049
- Blum, Howard F., 2881 N. E. 22 Court, Pompano Beach, Fla. 33062
- Blum, Mr. and Mrs. Robert M., 1916B Lombard St., Philadelphia, Pa. 19146 (Cowries, scallops)
- Boone, Mr. and Mrs. Hollis Q., 3706 Rice Blvd., Houston, Texas 77005
- Born, Mrs. Thomas, 4345 Menolette, Pensacola, Fla. 32504
- Boss, Dr. Kenneth Jay, Museum of Comparative Zoology, Cambridge, Mass. 02138
- Bottinger, L. J., Rte. 1, Box 50, Tow, Texas 78672 (Recent and fossil)
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- Brill, Mr. and Mrs. James A., 804 Johnson St., Terrell, Texas 75160
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- Broussard, Mrs. Grace, Rt. 2, Box 185, Beaumont, Texas 77705 (Sea shells of Gulf coast)
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- Buffalo Museum of Science, Research Library, Humboldt Parkway, Buffalo, N. Y. 14075
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- Burke, Alice L. and Thos. D., Jr., 1820 S. Austin Blvd., Cicero, Ill. 60650 (Marine mollusks of eastern U. S. A.)
- Burmeister, Carol, 310 Parker Ave., Algoma, Wisc. 54201 (Cowries, top shells and turbanes)
- Caffin, John, 528 W. New York Ave., DeLand, Fla. 32720 (World shells)
- California Institute of Technology, Millikan Library, Pasadena, Cal. 91109
- Campbell, Mrs. Minnie Lee, 3895 DuPont Circle, Jacksonville, Fla. 32205 (General collecting)
- Cardeza, R. Adm. and Mrs. Carlos M., P. O. Box 6746, Houston, Texas 77005 (Summer Address: 1718 Jewel Box Dr., Sanibel, Fla. 33957 (Florida and Texas shells)
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- Carlton, Jas. T., Dept. Invert. Zool., California Academy of Sciences, San Francisco, Cal. 94118 (Estuarine and brackish water mollusks)
- Carney, W. Patrick, U. S. Naval Medical Research Unit No. 2, Djakarta Detachment, APO San Francisco, Cal. 96356
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- Castagna, Michael, Virginia Inst. Marine Sciences, Wachapreague, Va. 23480 (Pelecypod larval behavior)
- Cate, Mr. and Mrs. Crawford N., P. O. Drawer R, Sanibel, Fla. 33957 (*Mitra*, *Cypraea*; no exchanges)
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- Clarke, Dr. Arthur H., Dept. of Mollusks, National Museums of Canada, Ottawa, Ontario K1A 0M8, Canada
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- Corgan, James X., Dept. Geography and Geology, Austin Peay State Univ., Clarksville, Tenn. 37040 (Microscopic gastropods)
- Cornell Univ., Albert R. Mann Library, Ithaca, N. Y. 14850
- Cotten, Mrs. Nadalyn, 299 Vincent Ave., Metairie, La. 70005 (Gulf of Mexico and West Indies)
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- Cutler, Henry H., 105 Abbott Rd., Wellesley Hills, Mass. 01570
- Cvancara, Dr. Alan Milton, Dept. Geology, Univ. of North Dakota, Grand Forks, N. Dak. 58201 (Pleistocene and Holocene continental mollusks; Early Tertiary continental and marine mollusks)
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- Dundee, Dr. Dolores S., Dept. Biol., Louisiana State Univ. in New Orleans, New Orleans, La. 70150 (Land mollusks; freshwater mussels)
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- Franzen, Dr. Dorothea, Illinois Wesleyan Univ., Bloomington, Ill. 61702
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- Geological Survey of Canada Library, Room 350, 601 Booth St., Ottawa, Ontario, Canada K1A 0E8
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- Gilmour, Thos. H. J., Dept. Biology, Univ. of Saskatchewan, Saskatoon, Saskatchewan, Canada (Anisomyarian bivalves)
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- Groeneveld, Miss Mae, 1183 Terrace St., Muskegon, Mich. 49442 (*Cypraea, Conus*)
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- Gunter, Dr. Gordon, Gulf Coast Research Lab., Ocean Springs, Miss. 39564 (Ostreidae)
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- Haven, Dr. Dexter, 336 Lafayette Rd., Yorktown, Va. 23490 (*Mercenaria mercenaria*, *Mya arenaria*, *Crassostrea virginica*)
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- Heck, Ralph L., P. O. Box 16712, Temple Terrace, Fla. 33617 (World gastropods, esp. *Conus*, *Cypraea*)
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- Henderson, Jerry G., 1729 N. W. Greenbrier Way, Seattle, Wash. 98177 (General interest)
- Hepler, Neil M. and Laura E., P. O. Box 461, Deerfield Beach, Fla. 33441 (Cephalopoda, *Conus*, *Cypraeidae*)
- Hermann, Mrs. Pat., Rt. 3, Box 324C, Panama City, Fla. 32401 (Land snails)
- Hernandez, Mr. and Mrs. Leonardo, 90 Park Terrace E., Apt. 6E, New York, N. Y. 10034 (Tropical Western Atlantic mollusks and Caribbean land mollusks)
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- Hoover, Mrs. G. R., 507 Cedar St., Ketchikan, Alaska 99901 (Amateur; for recreation, pleasure and aesthetic appreciation)
- Hopkins Marine Station Library of Stanford Univ., Pacific Grove, Cal. 93950
- Hornstein, Leon, 2211 Arden Rd., Baltimore, Md. 21209 (Amateur)
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- Lowry, Walter G. and Nelle H., 552 Old Lundy Rd., Macon, Ga. 31204 (Collect North Carolina marine; exchange for world marine)
- Lubarsky, Bernard and Mrs. Sue, 71 Barberry Dr., Berea, Ohio 44017 (General)
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- Luttrell, Mr. and Mrs. A. L., 5800 Wall Lane, Rockville, Md. 20852 (Marine and fossil)
- Lyons, Mr. and Mrs. Wm. G., Florida Dept. Nat. Resources, P. O. Drawer F, St. Petersburg, Fla. 33731 (Florida and West Indian mollusks)
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- Madden, Maurice J., Box 43, Pedricktown, N. J. 08067 (Shell collecting and identification)
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- Malone, Elsie, Sanibel Island, Fla. 33957 (Buy, sell exchange world shells)
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- Mann, Mrs. Julia, Data Research Associates, 425 Park Ave. S., New York, N. Y. 10016
- Maritimes Regional Library, Dept. of the Environment, Fisheries Service, P. O. Box 550, Halifax, Nova Scotia, Canada
- Marsh, Mrs. Therese C., P. O. Box 22291, Ft. Lauderdale, Fla. 33315 (S. E. Florida marine; world bivalves)
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- Southeast Missouri State College, Kent Library, William LeRoy, Cape Girardeau, Mo. 63701
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- U. S. Fish & Wildlife Service, Library, National Marine Fisheries Service, Tropical Atlantic Biological Lab., 75 Virginia Beach Drive, Miami, Fla. 33149
- University of Arizona Library, Tucson, Ariz. 85721
- Univ. of California at Los Angeles Geology Library, Los Angeles, Cal. 90024
- Univ. of Illinois Library, Urbana, Ill. 61803
- Univ. of Kentucky Library, Acquisitions Dept., Lexington, Ky. 40506
- Univ. of Maine Library, Orono, Me. 04473
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IN MEMORIAM

Mrs. Arthur H. (Louise) Clarke (January, 1973)
 Harold S. Colton (December, 1970)
 Dr. Leo G. Hertlein (January, 1972)
 Dr. William C. Starrett (December, 1971)
 Mrs. Edward L. Strater (July, 1971)

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NOTICE

Most scientific journals send manuscripts to qualified reviewers to assist authors in avoiding errors and in improving their papers. The AMU has now adopted a similar policy. The AMU Council will constitute our review board and beginning in 1973 all manuscripts except short abstracts will be sent to appropriate members of this review board (usually two) prior to acceptance for publication.

The AMU Bulletin has also adopted as its standard the *Style Manual for Biological Journals* published by the American Institute of Biological Sciences, Washington. All manuscripts accepted for publication become the property of the AMU and may be edited for style in accordance with this standard.

BULLETIN
OF THE
AMERICAN
MALACOLOGICAL
UNION, INC.

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BULLETIN

for 1973



AMU Thirty-Ninth Annual Meeting

THE AMERICAN MALACOLOGICAL UNION, INC.

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1973-1974

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Published
May 22, 1974

THE AMERICAN MALACOLOGICAL UNION, Inc.



BULLETIN
for 1973



AMU, Thirty-Ninth Annual Meeting

SPECIAL CONTRIBUTION

HISTORY OF THE AMERICAN MALACOLOGICAL UNION 1931-1973

*Margaret C. Teskey**

The American Malacological Union had its inception in 1929 or 1930. It began as an idea in the fertile mind of Mr. Norman Lermond, an energetic and individualistic Norwegian gentleman who operated a small natural history museum and arboretum in Thomaston, Maine. After discussing the merits of such an organization with his good friend, William J. Clench of Harvard, he dispatched the first of a series of letters to every person of his acquaintance of whom he had knowledge as being in any way interested in mollusks or their shells.

Response was so favorable that he named his movement the American Association of Conchologists, and called a meeting to organize. The meeting was held by invitation of Dr. Henry A. Pilsbry, at the Academy of Natural Sciences, Philadelphia, in April, 1931. By then 169 persons had sent in dues of twenty-five cents and were enrolled as charter members, and 29 of them attended the organizational meeting.

A constitution was drafted and adopted, the name American Malacological Union proposed and accepted, and Dr. Pilsbry was elected to be the first president after Mr. Lermond had declined the office. He chose instead to become corresponding secretary, but was not active; soon his duties were incorporated with those of Financial Secretary Imogene S. Robertson of Buffalo.

The following year a meeting was held at the U.S. National Museum, Washington, D.C. Several additions were made to the constitution, and Dr. Paul Bartsch was elected to succeed Dr. Pilsbry and to conduct the 1933 meeting at Harvard.

Over the following decade the AMU grew slowly but at a steady pace. Annual meetings were held at Stanford University (Junius Henderson, President), Buffalo Museum of Science (President Clench being out of the country and unable to preside, the meeting was conducted by Vice-President Calvin Goodrich), St. Petersburg, Florida (Goodrich), University of Michigan (Joshua L. Baily, Jr.), University of Havana, Cuba (Carlos de la Torre), Royal Ontario Museum of Zoology in Toronto, Canada (Maxwell Smith), again at the Academy of Natural Sciences in Philadelphia (H. B. Baker), then at the invitation of Mr. Lermond, at Rockland, Maine (Harald A. Rehder).

A part of the program at the Maine meeting (1941) was in the form of a collecting symposium, and several papers were read on the subject of collecting and preparing land, freshwater and marine mollusks. The Annual Bulletin in which these papers were printed was a handy reference source, so much in demand that in 1955 the symposium papers were to be incorporated into the popular AMU publication, *How to Collect Shells*.

World War II interrupted annual meetings for a period of four years, but by carrying on voluminous correspondence Imogene Robertson managed to compile and issue annual report bulletins for 1943 and 1944-45; in this last was reported the death of Norman Lermond at age 83.

The 1946 meeting was the twelfth, and a return visit to the U.S. National Museum; since President Louise M. Perry had resigned, Vice-President Henry van der Schalie occupied the chair. It was an especially joyous occasion, as old friends and new gathered to exchange news and experiences after so long an absence.

The offices of Corresponding and Financial secretaries had been held by Mrs. Robertson since the second year, and at this meeting they were formally incorporated into one; her husband, Harold R. Robertson, was elected to fill the newly created office of Treasurer.

The following year the AMU met for the second time on the Pacific coast, at Asilomar, in Pacific Grove, California; Dr. van der Schalie again conducted the meeting. On this occasion the idea of forming a west coast division was discussed informally. It received such favor that the following year (1948) the Pacific Division of the American Malacological Union was organized, and held the first annual meeting at Stanford, California.

The AMU convened that year at the Carnegie Museum at Pittsburgh (A. Myra Keen), and during succeeding years at the University of Miami (Elmer Berry), The Chicago Natural History Museum (Fritz Haas), then again in the Museum of Science in Buffalo (J. P. E. Morrison).

Harold Robertson had passed away earlier that year (1951), and Mrs. Robertson had assumed his duties along with her own. Her health, however, was failing and at the meeting in August she tendered her resignation. Termination of her long and faithful

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service was accepted with regret, and upon her recommendation Margaret C. Teskey was made Secretary-Treasurer.

Mounting popular interest was increasingly evident as local shell clubs were organized in California, New York and Florida. As each came into being it was invited to affiliate with the AMU as a member club; currently forty-nine local groups are in existence, and the annual accounting of their activities attests to the fact that the collection and study of shells holds a reward for all.

Annual AMU meetings continued with ever-mounting attendance. The Museum of Comparative Zoology at Harvard was re-visited in 1952 (Jeanne Schwengel), then for the first time meetings were held at the University of Kansas (A. Byron Leonard), the University of New Hampshire (Joseph C. Bequaert) and at Wagner College on Staten Island, New York (Morris K. Jacobson).

A revised constitution was adopted in 1954, containing a clause relating to the Pacific Division and its precepts; in 1956 the Pacific Division postponed their annual meeting and members went all out to entertain the AMU at San Diego (Allyn G. Smith). Peabody Museum at Yale University provided the site of the 1957 meeting (Ruth Turner). Dr. Pilsbry attended this meeting but died three months later at the age of ninety-five.

A repeat visit to the University of Michigan was made the following year (Aurèle La Rocque), then for the third time the AMU returned to its birthplace in Philadelphia (R. Tucker Abbott). Redpath Museum at McGill University in Montreal, Canada hosted the 1960 convention (Katherine V. W. Palmer), and next summer the AMU paid a third-time visit to the U.S. National Museum (Thomas E. Pulley). St. Petersburg again in 1962 (William K. Emerson) and the following year a third visit was made to the Buffalo Museum of Science (Albert R. Mead).

By now the AMU had achieved a recognized place among the scientific societies of the world, and listed among the corresponding members were names from such distant lands as Japan, the Philippines, Australia, Saudi Arabia, Yap, the Netherlands. The annual report bulletins had become a valued reference source since they contained abstracts of most of the papers read at both annual meetings, together with a constantly updated membership list complete with current addresses.

The AMU went to New Orleans in 1964 as guest of Louisiana State University in New Orleans (John Q. Burch), and adopted an extensive constitution, incorporating the By-Laws of the Pacific Division. Next year an invitation to return to Wagner College on Staten Island was accepted (Juan J. Parodiz), and the annual bulletin reporting this meeting was expanded to contain an index of all papers read since 1949.

By now a membership approaching 800 had created an intolerable workload for

Secretary-Treasurer Teskey, though relieved of a portion of her duties when in 1954 the Executive Council had created a new office, that of Publications Editor. George M. Moore was elected to fill it, succeeded in 1962 by Karl Jacobson who remained publications editor until 1972 when he resigned and his duties were assumed by Arthur H. Clarke who currently holds the office.

In 1962 the office of Secretary-Treasurer was separated and Jean M. Cate was elected AMU Treasurer, a post she held for three years, resigning then in favor of another Californian, Mae Dean Richart. Mrs. Richart resigned in 1966 and Mrs. H. B. Baker was elected and served until 1972. Myra Taylor is now AMU Treasurer.

The years and the AMU rolled along, with the annual meetings red letter days on the calendar of most of the country's malacologists, professional and amateur alike. The friendly attitude of professional malacologists towards the non-professional has long been remarked upon, creating camaraderie reflected in the success of over forty years of happy annual reunions.

The 1966 meeting at the University of North Carolina (Ralph W. Dexter) was such a meeting, as was the next when the AMU went north to meet in Ottawa, Canada, at the invitation of the National Museums of Canada (Leo G. Hertlein). Then to Corpus Christi, Texas in 1968, (Arthur H. Clarke) when six Texas shell clubs united to play host in lieu of university auspices. The Pacific Division became inactive during this year and was declared dissolved in 1972.

The University of Wisconsin — Green Bay welcomed the AMU to its campus at Marinette, Wisconsin (Joseph Rosewater) and at this meeting in her home town Secretary Teskey tendered her resignation to become effective the following year when the AMU convened in Key West, Florida (Alan G. Solem). At that meeting Marian S. Hubbard was elected Recording Secretary, her duties now to be shared by a Corresponding Secretary, Paul R. Jennewein. Both are currently in office. A much-amended and thoroughly revised constitution was adopted at this 1970 meeting.

The 1971 meeting was again held in Florida, at Coco Beach (David H. Stansbery). Next year Texas again beckoned, this time to Galveston (Arthur S. Merrill); Tucker Abbott entertained at the University of Delaware in 1973 (Dee Dundee). In 1974 Harold D. Murray will occupy the chair when the AMU visits Springfield, Massachusetts.

Forty-two years after its organization, nine charter members are still on the AMU roster: Carlos G. Aguayo, William J. Clench, Wendell O. Gregg, Ralph W. Jackson, Aurèle La Rocque, Katherine Van Winkle Palmer, Horace G. Richards, Allyn G. Smith, Druid Wilson. Six have been honored with life membership:

(Continued on page 68)

THE AMERICAN MALACOLOGICAL UNION, INC. THIRTY-NINTH ANNUAL MEETING

Newark and Greenville, Delaware June 24-28, 1973

Members started arriving at the campus of the University of Delaware in Newark on Sunday afternoon, June 24th. We went first to Clayton Hall where the smiling clerk handed us packets of room keys, information, tickets and our name tags all ready to pin on. Clayton Hall was the center of our activities for most of the convention. It looked "brand new", and had indeed been dedicated only the previous November. There was a large conversation area, several meeting rooms, a banquet hall, and a large auditorium with comfortable seats in raised tiers like a theater. We found no "ivy" on this new North Campus of the University but there were plenty of trees and a number of mockingbirds and other birds to serenade us. There were two types of rooms available. Both were air conditioned. Pencader A was a building that looked like a two-story motel. Rooms were entered directly from the outside. An inside door led to a short hall and the bathroom that was used by six or eight rooms. The other dormitory, Christiana Tower, looked like a modern apartment building, and operated like one, residents having a key for the outer door as well as a room key. First-time visitors from Pencader were shocked to find that they could not get into the building but students passing by saw our badges and cheerfully let us in.

After getting settled in our rooms, the next step was finding a place to eat supper. Most people went to a restaurant a few miles down the road, near Route 95. They had a long wait, as the restaurant was not equipped to cope with so many extra customers. A few of us chose the pizza place recommended by the desk clerks which was only a few hundred yards away. We were rewarded with excellent pizza and meatball heroes at modest prices. Then back to Clayton Hall for more getting acquainted and re-acquainted. On tables at the rear of the auditorium were displays of publications from the AMU and from several museums. Of prime interest to many was a pile of color plates from a publication of the Delaware Museum, with instructions to "take one". *Voluta junonia* was probably the most popular shell, and one smiling member was heard to say, "This is probably the only way I'll ever get one". Clayton Hall closed at 10 pm, but activity continued even later in some of the rooms and resumed in Clayton Hall on Monday morning as more members and visitors arrived. We had most of our meals at the university

cafeteria, a short walk from Clayton. The food was surprisingly good for institutional fare and no one went away hungry. (The only problem was an unusually early hour for dinner — the result of union problems with the cafeteria employees).

The 39th Annual Meeting of the AMU was officially convened at 11 am by President Dee Dundee. Introductory remarks were brief. Tucker Abbott, chairman of the local committee, was everywhere during the meeting — fixing microphones, solving problems, announcing details of many things such as bus pickups, and still had time to socialize. There were other people behind the scene, however, including Russ Jensen, members of the Wilmington Shell Club and Ken Bazata, our projectionist, who was isolated in a projection room for most of the 2½ days when papers were presented.

Papers were presented on Monday afternoon, and that evening was Shell Club Night. Unfortunately, the Executive Council had a meeting at the same time, and some of us had to miss the gathering of shell club members. The Council had so many things to discuss and decide upon (some of them controversial) that they had not finished by 11:10 when the staff finally closed Clayton Hall. That meeting was resumed on Tuesday night. With the Texans promising a party to start as soon as the meeting finished, the Council completed its deliberations in one hour.

On Tuesday we had our meetings at the Delaware Museum of Natural History in Greenville where we were delivered by bus about 9 am. We had time to look at the public displays, and then assembled in the 300-seat auditorium. Heads of many game animals were mounted high along the side walls of the auditorium. Mr. John I. DuPont welcomed the AMU members to his museum. Then we had the option of staying for two nature films or touring the parts of the museum normally closed to visitors. Those of us who went upstairs found Wilmington Shell Club members stationed along our tour route, explaining the different sections if necessary. Workers from the older, crowded, museums looked longingly at all the new shell cabinets with sections marked "for expansion", the glassed-in library and spacious work areas. As there were so many of us, we were not able to poke into the shell cabinets. We did see a few special shell displays in this area. Of particular interest was the museum's shell catalogue. Many of us were gratified to find that, as with our personal collections, Delaware had many shells numbered but

not named. On the way back downstairs we passed through a mezzanine with a number of offices, including the AMU library. This room now has furniture and cabinets as well as the AMU scrapbooks, old Annual Reports, shell club publications, and a small but increasing collection of memorabilia and pictures of shell collectors.

Papers were presented in the late morning and all afternoon. Lunch was held at the cafeteria of the Winterthur Museum near the Delaware Museum and supper was held back at the university. After supper Clayton Hall was again the center of interest. Dan Steger and Bob Lipe held a symposium on specimen photography, sharing their special techniques with interested members. Others made good use of the conversation corners in the reception area and later drifted off to private parties in Christiana Tower.

Wednesday morning was devoted to papers. At mid-day, some 210 of us went out into the blinding sunshine for our group photograph. This was about the brightest sun we had seen in three days of high humidity and pleasant temperatures. After lunch, the last papers were presented and the Annual Business Meeting was called to order at 3 pm. The minutes of that meeting are printed in this Bulletin. Perhaps the most notable vote was that in favor of a joint meeting with the Western Society of Malacologists on the west coast in the summer of 1975. So save up and plan to go west in '75.

The Annual Banquet was on Wednesday evening, with 210 in attendance. It was also held in Clayton Hall. At each place was a small dish of mints, the dishes made from scallop shells and decorated with various small shells. Place cards at the head table were held on a base of mushroom coral, decorated with small cowries and other shells. Each table had a lighted candle in a *Busycon* shell in the center and one of the six people at the table could take the candle. The lucky person was the one with a slip of paper under his or her chair, and the eager turning of chairs made for a wonderful "seventh inning stretch". On the head table were bouquets of beautiful hand-made shell "flowers"; and the most extraordinary eggs, decorated with beads, spangles, and tiny shells and pictures of seashells flat on the eggshells, like decoupage. The eggs were hung by loops from branches, very much like Christmas tree balls. After the delicious dinner came acknowledgements, introductions, and a film titled "Take Two from the Sea". This was promotional material for eating more clams and oysters, and was done in a humorous vein for the Department of Commerce.

Tucker Abbott made some introductions, in-

cluding our cook, Mohammed Solomon from Egypt. President Dundee introduced the head table and past presidents. She then took the opportunity to thank the teachers who had most influenced her, Dr. Dorothea Franzen and Dr. Henry van der Schalie, explaining with much levity how she went from snails and slugs to fresh water mussels and back again. She then went with much greater seriousness to her concern for the AMU, noting that there are very few younger members. It is possible that major changes will be required to make the AMU more truly a union of malacologists.

Thursday morning was a time for saying first farewells to those who were not going on the field trip to Lewes, Delaware. The morning was overcast, but two busses and a few cars left for Lewes at 9 am amid forecasts of an 80% chance of rain. We arrived at the beach around 11 am and the sun got brighter as we travelled there. It turned out to be a lovely day. We scoured the beach for what was there. Only a few of the luckier or more skillful turned up any live mollusks (mostly on mud flats back of the beach proper) but the beachcombing was interesting and whetted appetites for the brown-bagged lunches. Most tantalizing were the many fragments of angel wings, as much as four square inches in area, but no whole valves. We were told that no live ones have been found nearby within memory and no one knows where these fragments come from.

About 1:30 the busses took us to the nearby biological station to see how clams, oysters and lobsters were bred and raised in tanks, some to be put back into the bay or ocean on attaining the proper size. There was a nice, smelly flat exposed at low tide when we got to the research station. In addition to many small live snails, we saw live sea anemones, one almost two inches across the disc when contracted, and dead horseshoe crabs — the mature males with peculiarly hooked front claws. The young man who did not recognize an operculum turned out to be not the son of an inland land snail collector but a local reporter covering our outing. He was absolutely amazed at how much more we could see on the beach than *he* could see there.

Most of the cars left us there and headed for home in New Jersey, Pennsylvania or the Washington, D.C. area. The busses took the rest of us back to Clayton Hall through the same green fields. Many of us left for home immediately thereafter, but far-away travelers were allowed to stay at the college Thursday night. So off we all went with calls of, "See you in Springfield next year!"

Marian S. Hubbard, Recording Secretary

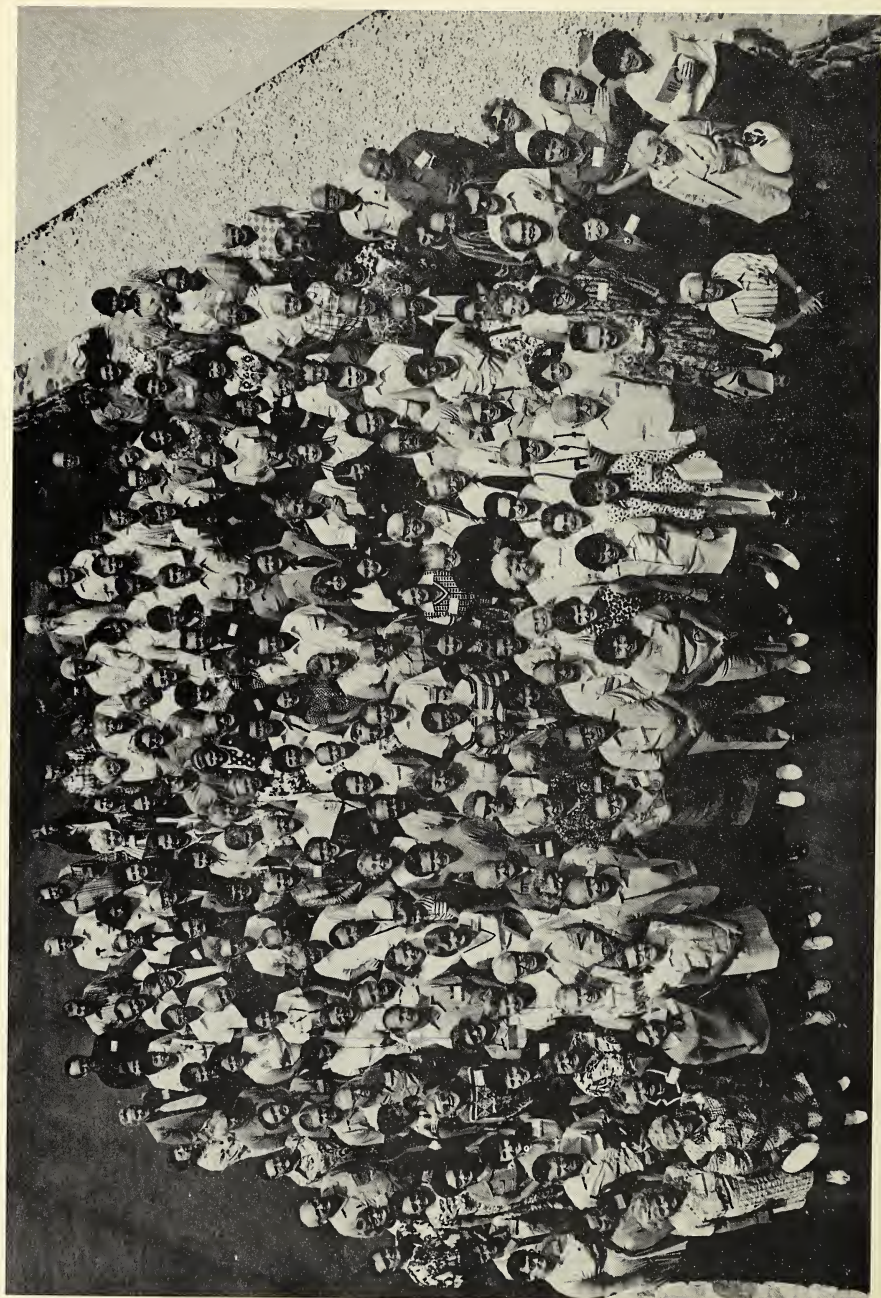
MEMBERS AND GUESTS IN ATTENDANCE AT THE 39th ANNUAL MEETING

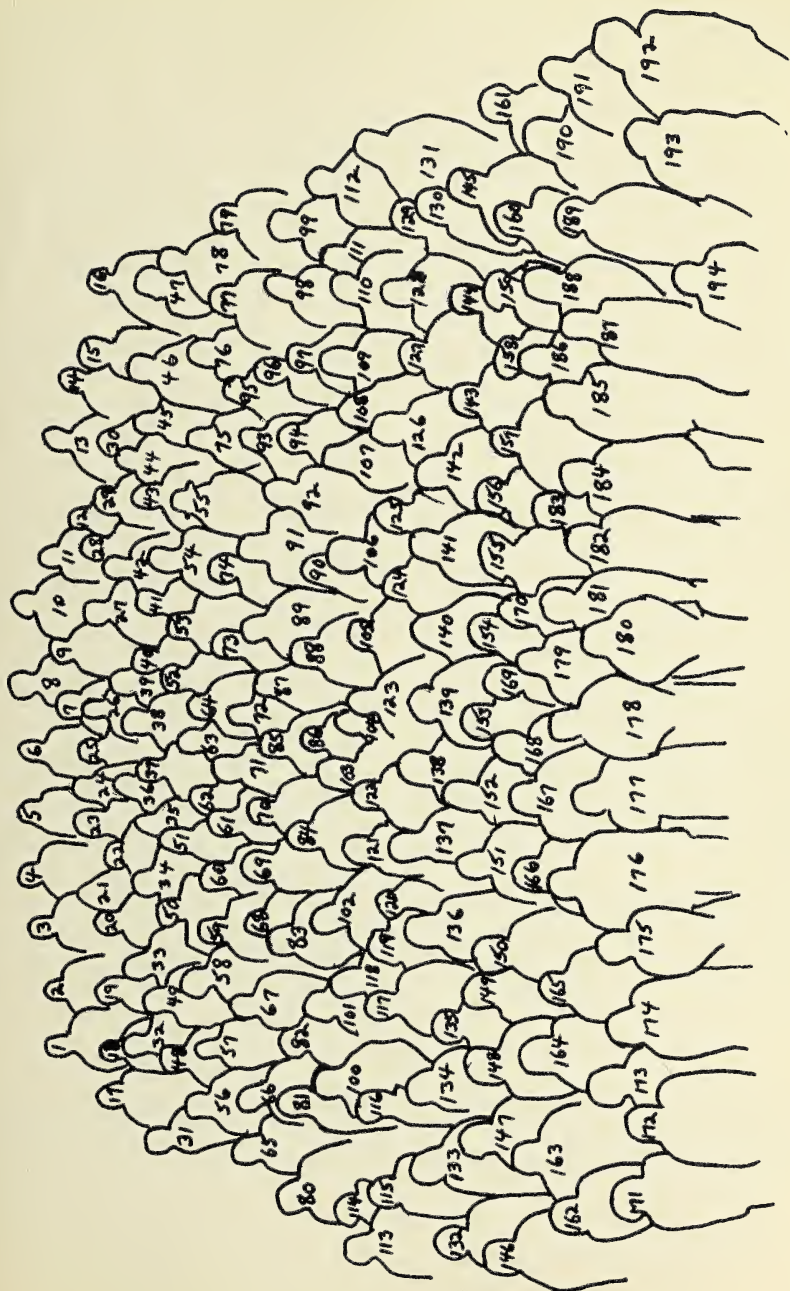
Group photograph identification:

1. James B. Sickel, 2. John W. Ropes, 3. Leslie Hubricht, 4. William Lloyd Pratt, 5. Susan Pratt, 6. Milton Werner, 7. Mathilde Weingartner, 8. William G. Lyons, 9. Saul D. Rotter, 10. Gordon Usticke, 11. M. Karl Jacobson, 12. Mattie Chanley, 13. Carl W. Gugler, 14. Ken Bazata, 15. Mique Pinkerton, 16. John Barr, 17. Donald T. Bosch, 18. Eloise Bosch, 19. Jack Foehrenbach, 20. Harold D. Murray, 21. Sue Davis, 22. H. Wallace Roberts, 23. Mattie Heist, 24. Florence Kuczynski, 25. Sophie Kuczynski, 26. William Reader, 27. Ted Katsigianis, 28. William Harman, 29. David Constantine, 30. Olive Lewis, 31. Dorothy Raeihle, 32. Virginia Orr Maes, 33. Daniel J. Bereza, 34. Harold Mills, 35. Vivian Mills, 36. Carol Lalli, 37. Thomas J. Banek, 38. Carol B. Suein, 39. Esther Reader, 40. E. J. Cetnar, 41. Barbara McGinn, 42. Thomas McGinn, 43. Clyde F. E. Roper, 44. Walter E. Sage III, 45. Ann Cohen, 46. Grace Rickard, 47. Martha Klinkey, 48. Ruth Shasky, 49. Donald Shasky, 50. Jerry Harasewych, 51. Helen K. King, 52. Veronica Cetnar, 53. Artie Metcalf, 54. Joseph R. Houbbrick, 55. Peter Myers, 56. Leigh Stacey, 57. Miriam Schriener, 58. Howard Schriener, 59. Eugene P. Keferl, 60. Jay Tripp, 61. Bonnie Oatis, 62. Mary Long, 63. Wilma Baker, 64. Anthon Bagdon, 65. Irene Stacey, 66. Sergio Fernandez, 67. Cherita Stark, 68. John Lewis, 69. Esther Lewis, 70. Leroy Heist, 71. Patricia Bagdon, 72. Prasong Temcharoen, 73. Mrs. T. Myers, 74. T. Myers, 75. Adelaide Johnstone, 76. Laura Hepler, 77. Al Avellanet, 78. Neil Hepler, 79. Helene Avellanet, 80. Hendryk B. Stenzel, 81. Hollis Boone, 82. Constance Boone, 83. Thomas Pulley, 84. Charles M. Courtney, 85. Ellen McHugh, 86. Juan Jose Parodiz, 87. K. Elaine Hoagland, 88. Mrs. William Hamilton, 89. George M. Davis, 90. Roberta Curington, 91. Hal Lewis, 92. Meredith L. Jones, 93. J. Dayton, 94. Esther Wheel, 95. Therese Marsh, 96. Ada Dayton, 97. Adlai Wheel, 98. Bessie Harris, 99. Major Marion Harris, 100. Wayne Holiman, 101. Myra L. Taylor, 102. Robert Robertson, 103. Gladys McCallum, 104. Esther Parodiz, 105. Carl Aslakson, 106. Ann Marti, 107. Jennifer Merrill, 108. Carolyn Jenkinson, 109. John Jenkinson, 110. Russell Jensen, 111. Jean Cate, 112. Crawford Cate, 113. R. Tucker Abbott, 114. Ruth D. Turner, 115. Dorothea Franzen, 116. Audrey Holiman, 117. Donald Moore, 118. Albert Taxson, 119. Cynthia Moore, 120. Walter Moore, 121. Anne Taxson, 122. Arthur H. Clarke, 123. John McCallum, 124. Marian Aslakson, 125. Esme Merrill, 126. Arthur Merrill, 127. Kenneth J. Boss, 128. Ralph Dexter, 129. Ann Adams, 130. Robert Janowski, 131. Elmo Adams, 132. Germaine L. Warmke, 133. Charlotte Johnson, 134. Veronica Johns, 135. Cornelia McInnes, 136. Harriet Riggs, 137. Hugh J. Porter, 138. Marguerite Thomas, 139. Jack Carnes, 140. Sue Carnes, 141. Aurèle LaRocque, 142. Henry van der Schalie, 143. Kirk W. Anders, 144. Dorothy Janowski, 145. David Stansbery, 146. Sarah Swartz, 147. Frieda Schilling, 148. HESSIE Kemper, 149. Mrs. David S. K. Corey, 150. Austin Barker, 151. Henry Dow, 152. Nellie Dow, 153. Albert Lindar, 154. Charlotte Lindar, 155. Miriam K. Hicks, 156. Mrs. A. LaRocque, 157. Dan Steger, 158. Katherine V. W. Palmer, 159. Juliette Compitello, 160. Lula B. Siekman, 161. Mary Lois Stansbery, 162. Betty Lipe, 163. Robert Lipe, 164. Katherine Seitz, 165. Ellen Barker, 166. Mrs. H. B. Baker, 167. William J. Clench, 168. Viola Perrault, 169. Twila Bratcher, 170. Miriam E. Porter, 171. Adaline Westerfield, 172. Ruth Craine, 173. Mrs. Ralph Dexter, 174. Ruth Greenberg, 175. Corinne Edwards, 176. William Bledsoe, 177. Betty Allen, 178. Lawrence Allen, 179. Paul Jennewein, 180. Doris Ferguson, 181. Marian Hubbard, 182. Dee S. Dundee, 183. Bobby Steger, 184. Jan Greenberg, 185. Elmer Neudecker, 186. Mildred Neudecker, 187. Kleinie Fieberg, 188. Alice Imlay, 189. Grace R. MacBride, 190. Mary Rosewater, 191. Joseph Rosewater, 192. Marc Imlay, 193. Hellen Notter, 194. John Ferguson.

Members and guests who were registered but are not in group photograph:

Katie Benson, David Bickel, K. David Brown, Paul Chanley, Carla Cicchi, Alfdis Courtney, Susan Cumins, Sue Evans, John and Magda Finlay, Stanley Fraser, Neil and Laura Hepler, Ginnie Jennewein, Lawrence E. Jerome, George L. Jerome, Gladys R. Jerome, Richard H. Jones, Judge and Mrs. Benjamin Lencher, Glenn Long, Elizabeth McKinley, Joseph and Dorothy Morrison, Jane M. Oram, Eileen Posey, Ruth Price, Lauralee Rappleye, Mary Ropes, Gary Rosenberg, Florence A. Ruhoff, Ronald Sasaki, Grace J. Thomas, Butch Weir, Jeannie Whiteside, Lucia Zoecher.





PAPERS READ AT AMU 39th
ANNUAL MEETING*

AMERICAN MALACOLOGISTS — A BIOGRAPHICAL SURVEY (1618-1973)

R. Tucker Abbott*

The American poet, Ralph Waldo Emerson, wrote over a hundred years ago that "there is properly no history; only biography." The history of American Malacologists (or conchologists, in the terminology of some) is also a web of biographies — the life story of people: early American explorers, farmers, naturalists, school teachers, scholars and physicians.

Among the ranks of pioneering shell collectors and mollusk students in America were a President of the United States (Thomas Jefferson), a Secretary of War (Joel Poinsett), several U.S. Senators, a dozen admirals and generals, a member of the Canadian Parliament, numerous judges, and six college presidents.

There has long been a need for a register or biographical reference book in the field of malacology, one similar to American Men and Women of Science or Who's Who in America, but one that would include the lives of amateur conchologists as well as professional, college-trained research workers. Malacology is unique among the American fields of scholarly endeavors because no other science has had so many devoted amateurs contribute so much to its reservoir of knowledge or to its general welfare and progress. In addition, there has been a need for an historical account, a sort of "Who Was Who," especially for research workers, curators, and historians.

American Malacologists was created in 1972 with R. Tucker Abbott as editor-in-chief, Miss M. E. Young as managing editor, and with the following consulting editors: Arthur H. Clarke, William J.

Clench, Ralph W. Dexter, Aurèle La Rocque, William E. Old, Jr., Allyn G. Smith, and Margaret C. Teskey. It was published in late 1973.

In addition to the main purpose of serving as a source book of current and past biographies, the editors have assembled and will keep on record an historical file of letters, papers, photographs and other data that someday will serve the community of science historians and students of malacology. We urge biographees to contribute such material for safekeeping for the use of generations to come. These archives will be deposited with the American Malacological Union or the Delaware Museum of Natural History in Greenville, Delaware.

Help is needed in completing the biographies of over 400 deceased persons who once worked with mollusks in the Americas, such as Mrs. George Andrews of Tennessee, Rev. E. R. Beadle of Philadelphia, Richard E. Call of Connecticut, and the Rev. J. Rowell of California, to name but a few. A list of these forgotten people is available from the editor-in-chief. It is hoped that interested students of malacological history will contribute additional information.

A second edition is planned for 1976, and those persons not already included in this first one may apply for a free application form from the publisher of *American Malacologists*. Photographs or early sketches of deceased malacologists and amateur conchologists are particularly needed for use in a forthcoming edition.

Plans have been launched to assemble and publish a *European Malacologists* and an *International Malacologists*. Details may be obtained from our editorial offices.

*Delaware Museum of Natural History, Greenville, DE. 19807.

*Author's manuscripts which contain substantially more than 300 words are considered as scientific papers. They have each been evaluated by appropriate referees and those which are acceptable have been

edited and are printed in this section. Shorter manuscripts are considered as abstracts. They have been edited (but not referred) and are printed in a following section.

HISTORICAL ANALYSIS

An analysis, however short, of the biographees is a measure of the current state of the science and hobby of malacology in the Americas. It should be born in mind that the contents in this first edition are far short of being a true representation of living malacologists, particularly from Central and South America.

The first edition of *American Malacologists* contains approximately 1,000 living registrants. Of the 3,500 applications mailed to members of shell clubs in the United States, members of the American Malacological Union, the American Society of Limnology and Oceanography, the National Shell-

fisheries Association and subscribers to such scientific journals as *The Nautilus* and *Indo-Pacific Mollusca*, about one third responded. We believe that the appearance of the first edition of *American Malacologists* will stimulate a large proportion of the non-respondents to apply for listing in the second edition. Among the probable reasons for not submitting applications are a dislike of filling out questionnaires; procrastination; lack of appreciation of the purposes and value of this project; present lack of interest in mollusks; and, in some cases, a feeling of not belonging in the directory.

LIVING MALACOLOGISTS

Geographical Distribution — A complete geographical index of biographees is included in the book. The highest number of biographees (155) live in California. The 1971 membership of the Western Society of Malacologists consists of 164 Californian residents, indicating that a majority of the more serious malacologists of that state responded to our applications. Florida was second with 127 biographees. Among the 10 leading states all were sea-board, except Pennsylvania and Illinois.

The states having the most biographees are, in descending order, California (15%), Florida (13%), New York (7%), Texas (7%), Pennsylvania (5%), Massachusetts (3.5%), New Jersey (3.1%), North Carolina (3%), Illinois (2.8%), Maryland (2.6%).

According to *The Naturalists Directory* of 1878, those interested in mollusks (205) were distributed as follows: New York (14%), California (13%), Massa-

chusetts (11.5%), Ohio (11%), Pennsylvania (8%), Illinois (5%), and Florida less than 1%. By 1895, New York had dropped to 10%, and Florida had risen to 3%. Ever since colonial days the drift has been from the northeastern quarter of the nation to the southwest and southeast.

Occupations — An accurate determination of the occupation of each biographee was sometimes difficult, and in some instances several occupations were listed for some people. The most difficult to ascertain properly was "housewife" or "homemaker", a term generally applied to a wife or a female head of the household. Of the 200 women listed (20% of the total biographees), only 101 claimed "homemaker" as an occupation, and often this was supplemental to being a teacher, librarian or nurse.

Among the 1,000 living registrants we found the following full or part-time occupations or activities.

		%
College professors (assistant prof. and above)	147	14.7
Homemakers; housewives	101	10.1
School teachers (below college level)	92	9.2
Authors of popular books and textbooks	58	5.8
Editors or consultants of professional mollusk journals	57	5.7
Museum directors	5	.5
<i>Occupations of Professional Malacologists (of 400 persons)</i>		%
Systematists; taxonomists; museum curators	107	27.0
Marine biologists (marine or zoologists)	106	26.5
Shellfishery biologists	86	21.5
Freshwater and land ecologists; limnologists	73	18.2
Paleontologists; Paleoconchologists	57	14.2
Parasitologists	12	3.0
Entomologists	8	2.0
Ethnoconchologists	3	.7

Occupations of Amateur Conchologists (of 600 persons)

		%
Homemakers (active or retired)	101	17.0
Teachers (below college level)	84	14.0
Physicians	44	7.3
Shell dealers	33	5.5
Engineers (civil, electrical, etc.)	29	4.9
Chemists, biochemists	27	4.5
Newspaper reporters; journalists	17	2.8
Accountants; statisticians	16	2.6
Professional artists; illustrators	14	2.3
U.S. Navy career personnel	14	2.3
Nurses	13	2.1
Ministers, priests, missionaries	9	1.5
Attorneys and judges	9	1.5
Librarians	9	1.5
Sociologists; social workers	7	1.1

Current Research Activities — The responses of the 400 living professional malacologists to the query concerning research activities was quite naturally a blend of past interest, research accomplishments and competency in certain subjects, on the one hand, and of current, new, exploratory research and awakening interests, on the other hand. It would also be expected that with some research workers interests would vary from year to year. In general terms, below are the research areas most frequently mentioned by the 400 professionals:

Biology and ecology of bivalves	62 persons
Biology of oysters	48
Marine community studies	48
Marine mollusk ecology	42
Aquaculture or mariculture	41
Freshwater mollusk ecology	36
Embryology and development	31
Biology of gastropods	29
Biochemistry of mollusks	24
Feeding habits	24
Pollution and oil spillage	22
Behavior of mollusks	22
Freshwater community studies	18
History of malacology	17

Systematic research — The nature of the question on the application did not permit an adequate response. Some research systematists are currently active in several groups of mollusks, but undoubtedly felt that their mention was not significant. It was surprising to learn how few competent taxonomists were currently working on some of the larger and more important families, such as the Turridae, Conidae, Cardiidae, Veneridae, to mention but a few groups that probably have less than a half-dozen workers. Among the 100 families and genera being taxonomically investigated at present, the following have the most workers:

Unionidae	23 persons
Pleuroceridae	13
Cephalopoda	10
<i>Corbicula</i>	9
Mactridae	8
Turridae	6

DECEASED MALACOLOGISTS

In the section of "Who Was Who in American Malacology," containing brief biographies of 535 deceased persons, we attempted to add, when known, any biographical sources. Obituaries appearing in the leading malacological and paleontological journals were an important source, as well as the various editions of *American Men of Science*, *Who's Who*, and Max Meisel's *A Bibliography of American Natural History*.

The occupations of these 535 were not unlike those of today, with teachers leading the field (127), then physicians (70), followed by paleontologists (54), ministers (20), newspaper editors and printers (17) and engineers (13).

It has been said that many naturalists and malacologists live to a ripe old age. We made a distributional curve of the ages at death and apparently the adage has some truth in it. Of 215 shell collectors born before 1850, one third of them lived to be over 81 years of age, 10 lived well into their 90's. The group of 205 born between 1850 and 1900 fared a little better, one third living beyond 82 and 13 living well into their 90's.

Among the well-known malacological nonagenarians were George H. Clapp of Pittsburgh (90), J. T. Gulick of Hawaii (91), Isaac Lea of Unionidae fame (94), E. L. Mark, embryologist at Harvard (99), H. A. Pilsbry of Philadelphia (94), two Cubans — Felipe Poey (90) and Carlos de la Torre (92), Julia Rogers who wrote *The Shell Book* (93) and D. Thaanum of Hawaii (96).

But dying young was the fate also of many famous mollusk workers: C. B. Adams (of yellow fever at the age of 39); baptist preacher, Daniel Barnes, author of many new unionids, killed falling from a stagecoach at 43; Dr. Bruce Campbell died in 1973 at the age of

39, William M. Gabb (39), Thomas Say, America's first conchologist of note (47), William Stimpson (49) and G. W. Tryon (49).

Among the odd facts is the case of two malacologists born about a hundred years apart — both were born in Boston, both graduated from Harvard, both died at the age of 44, and both died in a hospital in Rome — the two were Amos Binney and Richard W. Foster. Four shell collectors have been killed by trains, two have died of accidental arsenic poisoning, one of them being Henry Hemphill who used this poison to cure small land snails. The first auto fatality occurred in 1909, when Henry A. Ward of Ward's Natural History Establishment was killed. Lt. Joseph P. Couthouy, the Boston conchologist who survived the rigors of Wilkes' U.S. Exploring Expedition in the 1830's was felled by a bullet from a Confederate sniper's rifle as he stood at the turret of his civil war vessel in the swamps of Louisiana.

The earliest European shell collectors include John Josselyn (born 1618) who wrote about the shellfish of New England in 1672. The Roman Catholic priest, E. F. Kino, collected shells throughout the Gulf of California in 1685. An anonymous account of the oysters and mussels of Virginia was published in London in 1649. The first true systematic malacologist of American origin was Thomas Say of Philadelphia and, later, New Harmony, Indiana.

American Malacologists, a 495-page, hardbound book, is available for \$12.50 from the editorial headquarters at 6314 Waterway Drive, Falls Church, Virginia 22044. Biographees receive a 30 percent discount; institutional libraries a 10 percent discount. If billing is required, charges are made for postage and handling.

THE EFFECTS OF RESERVOIR CONSTRUCTION AND CANALIZATION ON THE MOLLUSKS OF THE UPPER DELAWARE WATERSHED

Willard N. Harman*

Lakes are ephemeral geological phenomena. The most stable, although dynamic, aquatic biotopes are our major rivers. As would be expected, our greatest diversity of freshwater mollusks occur in these environments. Unfortunately, many of our rivers, including the Delaware, are becoming chains of impoundments. In the Northeast these are constructed primarily for flood control and urban water supplies.

The construction of reservoirs in tropical climates has increased the populations of pulmonates that are vectors of schistosomiasis, causing serious health problems. However, the same impoundments eliminate mollusks specialized for existence in the erosional areas of rivers. Even snails adapted for life in impounded waters are often eliminated from comparatively deep, steep-sided reservoirs typical of those found in the Northeast. In lakes of this character, variable water levels preclude the development of stable shallow water communities. This has been so effective in removing snails that varying the water levels of impoundments has been used as a control measure for snails in tropical areas (Jobin, 1970).

One of the most serious effects of the construction of reservoirs is the destabilization of substrates and increased siltation. Canalization, often associated with the construction of highways, has the same effects, and has also been used for snail control (Palmer *et al.*, 1969). As a result of these activities silt is often found in suspension. This has an abrasive action on molluscan shells that erodes the periostracum, allowing carbonic acids to quickly corrode the CaCO_3 layers underneath. It also affects light penetration, reducing primary productivity and decreasing the dissolved oxygen levels. When this silt is deposited, it fills the spaces between rocks reducing most of the surface area for the growth of organisms and eliminating many benthic species. Bivalves are quickly buried and gastropod eggs do not develop properly (Chutter, 1969). This same phenomenon also increases the possibility of adsorption and absorption of various toxic chemicals (Cairns, 1968).

These activities have adversely affected more than three-fourths of the Delaware watershed north of the Beaverkill. The major streams exhibit vast reaches practically devoid of mollusks. In these waters, which

are used as water supplies for New York City, the water levels fluctuate as much as 20m annually, and daily changes of 2 m have been recorded. Aquatic plants, that provide food and cover for many mollusks, are unable to grow, and adult mollusks and their eggs are often stranded completely out of the water.

Drains from the deeper waters of these reservoirs normally maintain extremely low temperatures throughout the year in the streams below them. This reduces productivity, resulting in extremely low food supplies, very slow growth and inhibition of reproduction. Variable amounts of precipitation, typical of the Northeast, result in ephemerally large flows of water out of these reservoirs (compared to the usual restricted flow) which often flushes snails away in the downstream areas. This technique has also been artificially induced and utilized as a snail control procedure (Jobin and Ippen, 1964).

Figure 1 illustrates a typical situation in which the species of mollusks present in an area increase as one moves downstream from the headwaters. Apparently this is a result of the waters becoming larger, more chemically and physically stable, and therefore more conducive to inhabitation. The example is the relatively undisturbed Chenango River in east-central New York State. The coarse stippling indicates areas where 10 or more species of mollusks are found; the fine stippling indicates from 5 to 9 species; the outlined areas, from 2 to 4; and no pattern indicates 1 or less.

In the Delaware (Figure 2) we see the effects of reservoir construction and canalization. Note the normal increase in species numbers above the impoundments and how the populations are now isolated from each other in tributaries that enter the reservoirs. For 10 to 20 miles below the reservoirs the cold water precludes the development of stable populations although some specimens are found that have presumably washed from the tributaries. Canalization along route 17 (the heavy dark line) has disrupted species along its right of way. It can be seen that where meanders of the river were left undisturbed, greater numbers of species still maintain themselves.

The group most seriously affected appears to be the larger bivalves. The only habitat that retains an apparently normal bivalve fauna is just above the Cannonsville reservoir. In that locality we have collected *Anodonta cataracta*, *Alasmidonta undulata*,

* Dept. of Biology, S.U.N.Y. at Oneonta, N.Y. 13820.

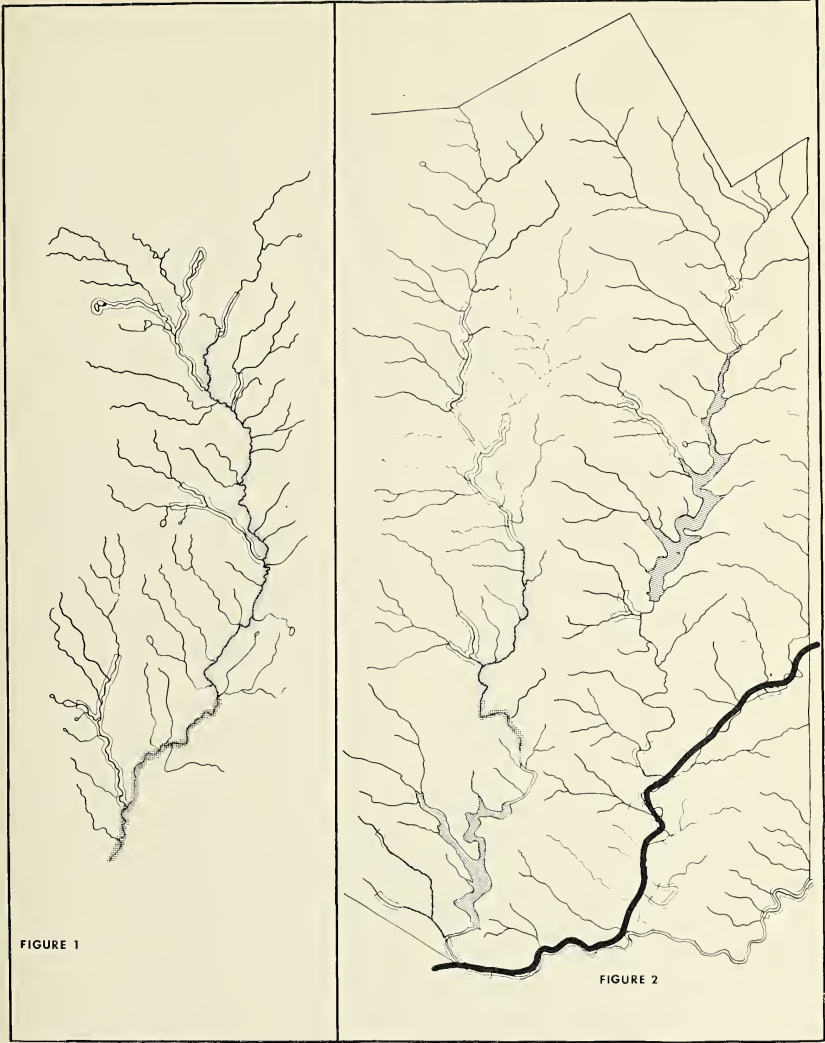


FIGURE 1

FIGURE 2

Fig. 1, Chenango River, New York. Fig. 2, Upper Delaware River, New York.

See text for explanation.

A. marginata, *Strophitus undulatus* and *Elliptio complanatus*, along with the prosobranchs *Cameloma decusum* and *Ammicola limosa* and several pulmonate snails, including the limpet *Ferrissia rivularis*. In many other localities bivalves are absent and mollusks are represented only by a few tolerant pulmonates such as *Gyraulus parvus*, *Helisoma* spp. and *Physa* spp.

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BIOLOGICAL AND PHYSICAL CAUSES OF MORTALITY IN NEW ENGLAND *CREPIDULA* SPECIES

K. Elaine Hoagland*

Mortality in *Crepidula* species is notable for its seasonal and year-to-year variability (Adam and Leloup, 1934). It is of interest economically since *Crepidula* are attacked by many of the same predators as oysters, yet the two groups differ in susceptibility to physical mortality factors (Korringa, 1946). This present report summarizes preliminary qualitative investigations into causes of death in adult populations of *C. fornicata*, *C. plana*, and *C. convexa*, the three species found in New England.

Table 1 details known causes of death and reduced viability in New England *Crepidula*. Except where a literature citation is given, data were obtained from field observations at Nahant, Woods Hole, Vineyard Haven, and Duxbury, Massachusetts, supplemented by laboratory tests.

Some factors are not by themselves usually fatal, but contribute to mortality in concert with other factors (see asterisks in Table 1). Such synergistic effects have been demonstrated in the laboratory. For example, *C. fornicata* stressed by low oxygen were more adversely affected by a temperature increase from 10°C to 20°C than were animals held under continuous aeration. Oxygen needs increase with temperature in metabolic processes. *Crepidula* maintained on suboptimal food were more easily pried loose by crabs and starfish than well-fed animals. In nature, those animals whose shells are infested by *Cliona* or *Polydora* must put energy into shell repair that they would otherwise use in body maintenance and reproduction. Also, a shell riddled by *Cliona* provides increased surface area for fungal growth.

Interspecific competition for space is often a factor in death of *Crepidula*. It forces them into marginal habitats, where they are less well protected against physical causes of mortality and more available to predators. Marginal habitats for *C. fornicata* at Nahant are the rocky-shore tidepools surrounded by soft, unsuitable substrate and by submerged rocks covered with algae. Temperature fluctuations and exposure to the air at low tide cause high mortality of spat in these tidepools. Fast-growing barnacles and colonial tunicates sometimes grow over *Crepidula* and kill them outright, as observed on spat collectors put out at Woods Hole.

Crepidula maintained in water tables in the laboratory are often attacked by fungi, bacteria, and protozoa. Only in areas of restricted circulation are these factors expected to be important in nature. *Crepidula* are also attacked by trematode cercaria; they commonly cause resorption of the gonads without killing the adult. Chemicals such as copper sulfate are used commercially to kill *Crepidula* on oyster shells (Walne, 1956). All three New England species thrive in water containing organic pollution and oil scum, although large amounts of oil interfere with respiratory and feeding functions of the gill.

Exact ranking of mortality factors is not yet possible, but different rank orders are expected for different geographical areas and substrate types. Off Vineyard Haven, in 10 to 20 feet of water on a muddy bottom, starfish are very abundant and predacious gastropods are rare. Less than 1% of empty shells examined had been drilled. In Woods Hole, drilling gastropods are relatively unimportant macropredators compared with flatworms, crabs, and starfish, yet about 5% of all *C. fornicata* beach shells collected in one year were drilled. The percentage was less for the other species. The proportion of drilled

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shells increases in summer months. Drilled *C. fornicata* fall between 15 and 25 mm in length with few exceptions, showing predator size-selection. Only one of a sample of fifty *C. fornicata* kept in a tank with *Urosalpinx cinerea* and *Nuccella lapillus* from September to April was drilled, indicating low winter predation by these organisms. Both snails have been observed feeding on *C. fornicata* in Woods Hole, the locality from which specimens for the experiment were collected.

A look at Table 1 reveals that *C. fornicata* is subject to a greater number of predators than the other two species. *Crepidula* living on rocky substrates are not subject to predation by *Lunatia heros*, but *C. fornicata* can be attacked if living in stacks on muddy bottoms. The animals directly in contact with the soft substrate in which *Lunatia* live are vulnerable. Stacking of *C. fornicata* increases local density and consequently these animals are more affected by such density-dependent predators as starfish. Hancock (1955) and Paine (1969) have reported that starfish establish food-preference hierarchies based on energy value and ease of capture of prey. Starfish should take *C. fornicata* when it is the most abundant (in terms of biomass) and easily-obtained species among available prey. Laboratory studies revealed that small starfish up to 150 mm in diameter can detach healthy *C. fornicata* up to 20 mm in length, so they are restricted to the juveniles and males at the top of the stacks. In Vineyard Haven, however, large starfish take a heavy toll on *C. fornicata* adults which range from 20 to 50 mm long (John S. Rankin, personal communication).

Of stacked *C. fornicata* dredged from mud off Vineyard Haven, 80% were infested with boring worms, and 30% with *Cliona*. Such shell infestations are less common in animals attached to rocks, and are rare in animals found at the low tide line. Tide line populations are so often killed by abiotic factors and washed ashore that their shells are poor homes for boring symbionts.

The alga *Codium fragile* is responsible for deaths of stacked *C. fornicata*. It attaches to clumps of shells, and as it grows, it floats them and increases the chances of their being washed ashore. This is very important in the Vineyard Haven population, where *Codium* is a recent invader (Fralick and Mathieson, 1973) to which *Crepidula* has not evolved a protective mechanism. Another unusual mode of death in *C. fornicata* comes about when the snails attach to the underside of a horseshoe crab which then molts or dies and the crab's carapace or body washes ashore, stranding the *Crepidula*.

Crepidula plana is subject to the same causes of mortality as *C. fornicata* when located on an exposed surface. In its preferred habitat inside an empty snail shell it is less easily destroyed by macropredators, except flatworms. A shell also occupied by a hermit crab offers even greater protection. Spat settlement experiments showed that *C. plana* settled

preferentially on shaded, concave surfaces and that spat attaching to exposed surfaces subsequently moved to protected areas. Among the *Crepidula*, *C. plana* has the least clinging ability for its size, and its habit of living in a protected cavity has partially reduced the need for a strong foot. When protected space is limited, *C. plana* spat settle on rocks and suffer high mortality.

Crepidula convexa has the greatest tolerance to desiccation and changes in salinity and temperature of the three species. It usually lives on the shells of living gastropods, thereby being subject to the host's predators. It is the most mobile of the *Crepidula*, and therefore is not as affected by overgrowth or other interspecific competition. Population density of *C. convexa* is lower than for the other species in all localities studied. Numbers are regulated primarily by restricted births — fewer eggs are laid per female (60-300 per brood) than for either *C. plana* (2,000-9,000) or *C. fornicata* (4,000-15,000). Low density and small size of individuals make *C. convexa* insignificant prey to drilling snails and other large predators.

In the *Crepidula* species, as in all living organisms, "old age" death takes place through intrinsic deterioration of body processes (referred to as accumulation of somatic mutations). In all species, mortality rate is inversely proportional to age and size. Major predators change with substrate type and water depth as well as with the species. Species differences in mortality are based partly on ecological specializations such as substrate preference. The ratio of abiotic to biotic mortality depends on the time of year, water depth, and density and age structure of the population.

C. fornicata is vulnerable to the greatest number and intensity of mortality factors, due to its size, abundance, and orientation on exposed surfaces. It has the highest reproduction rate and is the most densely packed of the three species in the regions studied. It acts as an energy funnel from the plankton to carnivores and decomposers. Where plentiful, *C. fornicata* absorbs a large portion of the energy of the ecosystem and plays a key role in energy flow and nutrient cycling. Therefore, its means of death are important factors in ecosystem interactions. *C. plana* and *C. convexa* are not present in such quantity as to play this role.

Extrinsic mortality factors place selection pressure on life history parameters such as birth rate and age at maturity. In *C. fornicata*, populations living in stacks on muddy substrates are subject to density-dependent predation. We expect an evolutionary trend toward production of fewer offspring with more energy devoted to each one. On the other hand, populations living on rocks at the low tide line are subject to intense density-independent mortality from physical factors. For these individuals, there should be a tendency toward greater numbers of offspring. In the Woods Hole area, the two habitats

TABLE 1: SOME MORTALITY FACTORS IN NEW ENGLAND POPULATIONS OF *CREPIDULA*

Macro Predators	Micro Predators	Other Biological Factors	Physical Factors	Chemical Factors
<i>C. fornicata</i> :	Fungi ⁴	<i>Cliona celata</i> (sponge)*	Ice crystals & scour	HgCl ₂ (1:15,000) ^{4,5}
<i>Asterias</i> species	Bacteria	<i>Polydora</i> species*	Siltation	CuSO ₄
<i>Cancer borealis</i>	Parasitic copepods ⁴	Mussel overgrowth*	Low oxygen	Zn
<i>Tautoga onitis</i> ¹	Sporozoans ⁴	Barnacle overgrowth	Low salinity #	Pb
<i>Platynonectes limanda</i> ²	Ciliate protozoans	Tunicate overgrowth	Sand scour	Other metals (not tested)
<i>Urosalpinx cinerea</i>	Algal shell borers	Codium buoy effect*	Desiccation	
<i>Nucella lapillus</i>	Trematode cercaria*	Transportation by host to unsuitable location (eg. horseshoe crab)	Abrupt temperature change #	
<i>Tritonalia iranicus</i> ²		Inadequate food supply*#		
<i>Lunatia heros</i>				
<i>Odostomia</i> species*				
Polyclad flatworms ³				
Predacious polychaetes				
<i>C. plana</i> inside dead shells:				
<i>Cancer borealis</i>	Fungi ⁴	<i>Cliona celata</i> *	Ice crystals and scour	HgCl ₂
<i>Urosalpinx cinerea</i>	Bacteria	Intraspecific space competition	Siltation	CuSO ₄
<i>Nucella lapillus</i>	Parasitic copepods ⁴	Transportation by host to unsuitable location	Low oxygen	Zn
<i>Odostomia</i> species*	Sporozoans ⁴	Inadequate food supply*#	Low salinity	Pb
Polyclad flatworms ³	Ciliate protozoans		Desiccation	
Predacious polychaetes	Algal shell borers		Abrupt temperature change #	
	Trematode cercaria*			
<i>C. convexa</i> on live snail host:				
Small <i>Cancer borealis</i>	Fungi ⁴	Transportation by host to unsuitable location	Ice crystals & scour	HgCl ₂
<i>Urosalpinx cinerea</i> (rarely)	Bacteria	Inadequate food supply*#	Siltation (rarely)	CuSO ₄
Small <i>Asterias</i> (rarely)	Parasitic copepods ⁴		Low oxygen	Zn
Marine birds	Sporozoans ⁴		Low salinity	Pb
<i>Odostomia</i> species*	Ciliate protozoans		Desiccation	
Polyclad flatworms ³	Trematode cercaria*		Sand scour	
			Abrupt temperature change #	

¹ Verrill and Smith, 1874² Adam and Leloup, 1934³ Frank, 1965⁴ Korringer, 1952⁵ Walne, 1956

Factors which by themselves are not usually fatal.

* Factors known to cause death under lab conditions, but of uncertain importance in nature.

are connected by a planktonic larval stage and no genetic isolation occurs, hence these trends are not realized. Yet there is an environmentally-induced mechanism by which animals living in the dense populations are able to postpone the sex change from male to female and effectively reduce the number of offspring produced in the lifetime of each individual. This kind of adjustment in reproduction can be considered as an energy-saving defense against predators which attack only when there are large numbers of the prey species available.

ACKNOWLEDGEMENT

I thank R. D. Turner for helpful suggestions and for reading the manuscript.

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REMARKS ON THE MARINE MOLLUSCAN FAUNA OF NORTHERN SOUTH AMERICA

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I think that most people believe the northern coast of South America — from French Guiana to Panama — to be a tropical paradise: sandy beaches with coconut palms and the coral reef lying a little offshore. This is far from the truth. Nearly half of this coastline is low lying, swampy, and with muddy bottom offshore. The remainder of the coast is largely mountainous, and the bottom usually drops away rapidly. There are some few islands with coral reefs between Trinidad and Aruba, a distance of around 750 kilometers. Corals live, of course, along the rocky shoreline of the mountainous area, but the only reef development may be along the sides of small steep sided bays indenting the coastline. The bottom of the bay is soft mud, while sand is usually found offshore along the open coast.

The molluscan fauna is composed of wide-ranging West Indian species and an endemic element that is as yet rather poorly known. While the mollusks have been somewhat neglected, a number of papers have been published during the last 100 years. Among these are Higgins (1876), Dautzenberg (1900), Bentham Jutting (1927), Coomans (1958), Rodriguez

(1959), Rehder (1962), Bullis (1964), Work (1969), Kaufmann and Götting (1970), and Altena (1971).

Some of the above investigations were confined to coral reef areas. Most of the species listed in these works are common to much of the tropical western Atlantic. In the paper by Altena (1971), however, on the bivalve Mollusca of Surinam, approximately 25% of the species comprise the endemic faunal element. One third of these have been recently described by Altena.

In November 1972, I visited the Instituto Colombo-Aleman, Santa Marta, Colombia. While there I collected by diving in shallow water on both sandy and rocky bottoms and also on a small coral reef clinging to the side of Ensenada de Concha. The most interesting material, however, came from a series of bottom grabs from the muddy bottom of the bay, 20 to 35 m in depth.

These samples contained considerable numbers of small gastropods and scaphopods but these were greatly outnumbered by the bivalves. Two species of *Nucula*, *N. dalmasi* Dautzenberg, 1900, and *N. venezuelana* Weisbord, 1964, were fairly common. Both species have been reported from Surinam by Altena and both are known only from the northern coast of South America. Other bivalves included

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Nuculana chazaliei (Dautzenberg, 1900), and *Tellina versluysi* Dautzenberg, 1900. Santa Marta is the type locality for both species. *Limopsis antillensis* Dall, 1881, would have been a surprise, but Altena had already found it at Surinam. The most abundant bivalve appears to be a small lucinoid, *Parvulucina (Microloripes) clenchi* (Altena, 1968). There were hundreds of specimens, many showing signs of maturity, but the largest was only 1.2 mm long.

Of the above identified species, *Limopsis antillensis* and *Tellina versluysi* (this species synonymized with *T. martinicensis* d'Orbigny by Boss, 1966) range into the northern Caribbean. The others appear to be confined to the northern coast of South America.

This work, of course, covers much too small a proportion of the fauna to enable more than a general statement to be made. However, it is now apparent that a number of shallow water species are only found along the northern coast of South America. The percentage of species making up this portion of the fauna will not be known for some time. As stated above, a rough count of Altena's bivalves from Surinam shows about 25% endemic to the region. I expect that this figure is too high since Surinam is a mud and sand region, but it does indicate the presence of an important faunal element in the tropical western Atlantic.

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DIPLODON CHARRUANUS (d'Orbigny): A REVISION

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The species *Diplodon charruanus* (d'Orbigny, 1835) (Unionacea, Hyriidae) is typical of, and almost restricted to, Uruguay. Although it is abundant, within the genus it is one of the species most frequently misidentified. While revising several museum collections I found many specimens labelled *D. charruanus* which belong to several different species, and also the true *D. charruanus* under other species names. Furthermore, in the literature its synonymy has included many names which are not synonyms.

Such confusion is not just the result of the variability of the species; actually *D. charruanus* is less variable than species in other groups of *Diplodon*, e.g. *D. delondontus* (Lamarck) and *D. burroughianus* (Lea).

D. charruanus was described by d'Orbigny in 1835 and it was repeated with added illustrations in 1842.

The type lot was accessioned in the British Museum in 1854. Johnson (1971) designated a lectotype from the Rosario River, Dept. of Colonia, Uruguay, plus 12 lectoparatypes. In 1868, G. B. Sowerby II gave a description under the name *Unio charruanus*, but his illustration was entitled as belonging to the "var." *rhuauciois*. Actually the illustration is of typical *D. charruanus*, Sowerby having confused the original figures in d'Orbigny. *Diplodon rhuauciois* (d'Orbigny) is an entirely different species but the mistake was perpetuated in the literature. Even Ortmann (1921) synonymized *D. rhuauciois* under *D. charruanus*.

In 1914 Simpson supplemented the previous descriptions of *D. charruanus* from observations he made on specimens from Isaac Lea's collection. Lea had indicated that the specimens had been received from d'Orbigny. Thus, in each of the three descriptions of *D. charruanus* up to that time, those of d'Orbigny, Sowerby and Simpson, there are

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indicated characteristics in each which are lacking in the other two.

Meanwhile, it had been overlooked that Lea in 1860 had described a new species as *Unio lepidus*, a name which, being preoccupied, Lea himself changed to *lepidior* in 1870. Its description contains all the characteristics which the other authors had added to *D. charruanus* and the illustration also shows it to be that species.

In his very important work "South American Naiads" Ortmann (1921) produced a redescription of *Diplodon charruanus*. It was exhaustive in every detail, but unfortunately, none of the specimens that Ortmann had at that time in the Carnegie Museum collection were actually *D. charruanus*. Surprisingly, he too overlooked the mistakes of Sowerby and Lea. The specimens he referred to as *D. charruanus* from Santa Isabel in Uruguay belong to another species described by Ortmann himself as *Diplodon berthae*. On the pages following *D. charruanus*, Ortmann also gave a full description of *Diplodon piceus* (Lea). This was what Haas (1930) thought to be the true *D. charruanus*, and in most modern collections this is the species labelled as *D. charruanus*. Recently I had the opportunity to revise the collection at the Seckenberg Museum studied by Haas and I found that in the lots he had labelled *D. charruanus*, specimens of *D. charruanus* and *D. piceus* are mixed.

The main difference that Ortmann found between the specimens he called *D. charruanus* and *D. piceus* was that the first grows from nonparasitic and hookless glochidia, while in *D. piceus* he detected hooks. These facts were confirmed by Bonetto working on living material, but it must be remembered that Ortmann had seen only glochidia of *D. berthae*, which is hookless and non-parasitic as in *D. charruanus*. Because of this similarity in larvae, Bonetto, following Haas' synonymy, included *D. berthae* under *D. charruanus*.

Owing to confused nomenclature, and the large number of names wrongly accepted as synonyms, it was believed that *D. charruanus* had a wide distribution in the Parana, Uruguay and La Plata rivers. Actually *D. charruanus* does not inhabit the large rivers but is found only in smaller streams of Uruguay, mainly in the southwest, although a few populations have also been recorded from across the border in the southernmost part of Brazil.

The shells of *Diplodon charruanus* have a shiny green-brownish periostracum, darker on the posterior half, with angulated posterior margin. The umbos show strong radial sculpture, and the posterior wing is marked with flutings. The cardinal tooth is trifid. It does not demonstrate unusual clinal variation.

Diplodon piceus differs by its opaque, totally black periostracum, less angulated posterior and more oval outline, virtual absence of a wing and absence of flutings. The cardinal tooth is less complex than in *D. charruanus*, bifid but stronger. The valves are generally thicker and heavier. Gerontic specimens, especially those from rapid streams, have eroded umbones and look like *D. uruguayensis* (Lea). It occupies a larger geographical area extending from the Argentina province of Entre Rios across central Uruguay into southern Brazil and exhibits conspicuous clinal variation.

When these differences are recognized, it is not difficult to separate the two species. Often it has been said that species in the genus *Diplodon* are very difficult, or sometimes impossible, to tell apart by the shells alone. That is an overstatement. Larval features are of course of great importance in distinguishing genera, subgenera, or groups of species. At the species level, however, two species which in the larval stage may look almost identical may show features in their subsequent development into adults which are remarkable enough to distinguish them completely.

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MOLLUSKS FROM M/V EASTWARD STATIONS 11542 AND 11545 EAST OF CHARLESTON, S.C.

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Sand-inhabiting fauna east of Charleston, South Carolina, was sampled twice on March 16, 1969 during cruise E-50L-69 of the Duke University M/V Eastward while searching for a southern extension of the offshore-reef system of North Carolina (Macintyre and Pilkey, 1969, Menzies *et al.* (1966). Sampling at both stations (#11542 & 11545, see Table 1) was by "small biological trawl", 1/4" bar mesh size. Sediment from each station was washed through a series of wire screens, the smallest having 1/8" bar mesh and screened remains were sorted under a binocular microscope. Fine sand occurred at #11542 but that at #11545 was much coarser and was difficult to wash through the 1/8" mesh screen. The latter station was also near a small ridge.

Station # 11545 (coarse sand and 50 m depth) contained 90 species of mollusks (Table 2). Species most abundant were: *Solariaella lacunella*, *Anachis pretii* cf., *Psarostola minor*, *Prunum virginianum*, *Viridillia cerviana*, *Cadulus quadridentatus*, *Dentalium sowerbyi*, *D. taphrium*, and *Notocorbula operculata*. Few bivalve species were abundant.

The deeper water station #11542, with its fine-grained sediment, had only 63 species of mollusks represented (Table 2). Most abundant were: *Arene variabilis*, *Niso aeglees*, *Olivella bullula*, *Terebra protexta*, *Turbonilla* cf. *dalli*, *Scaphander watsoni*, *Dentalium laqueatum*, *D. sowerbyi*, *Nucula crenulata*, *Nuculana acuta*, *Limopsis sulcata*, *Tellina squamifera*, *Verticordia fisheriana*, and *V. ornata*. The abundance of bivalves at this station unlike the previous may be attributed partly to the fineness of its substrate.

Of 144 different mollusks reported, 28 may be new records for South Carolina waters (Table 2).

Only ten species occurred at both stations and of these only one, *Dentalium sowerbyi*, was common at both.

Shoemaker (1972) listed 48 molluscan species occurring on the South Carolina offshore calcareous reefs. Of these, only eight were similar to those from the sandy area of #11545 and 11542. The overlap of occurrence by these reef mollusks for station #11545 was 9% and for station #11542 was 0%. This low degree of overlap may have been affected by the rock dredge used by Shoemaker. His dredge had larger

mesh size than the "small biological trawl" and thus was unable to retain smaller forms.

Comparison of molluscan species caught (unpublished U.N.C. Institute of Marine Sciences data) from the calcareous reef area off the North Carolina coast, 50-140 m depth, with species from stations #11545 and 11542, shows a much greater similarity than that exhibited by the samples of Shoemaker and stations #11545 and 11542. Sixty-nine percent of the mollusks of station #11545 and 57% of the mollusks of #11542 have also been collected from North Carolina reefs. Samples from the North Carolina reef area were taken by "small biological trawl" and the rock dredge. Although most North Carolina samples are from reef outcroppings, some included varying amounts of sand from the back- and fore-reef areas. This latter may account for the greater species overlap between the North Carolina and the #11545 and #11542 areas than between the Shoemaker species and those from #11545 and 11542 stations.

Comparison was also made of molluscan species caught (unpublished U.N.C. Institute of Marine Sciences data) from a shallow area (26-29 m depth) east of Cape Fear, North Carolina, containing a bed of *Glycymeris americana* (Table 1) with those from stations #11545 and 11542. Forty-eight percent of the mollusks from station #11545 and 11% from #11542 had also been collected on the glycymerid bed.

Analysis of data suggests that molluscan fauna from the two stations, #11545 and #11542, is quite diverse and that the fauna of each station is dissimilar. As station #11545 (50 m depth) exhibits a greater overlap of molluscan species with the glycymerid bed (26-29 m depth) than does #11542 (depth 150 m), it is suggested that much of this dissimilarity may be attributed to depth. Further, the high degree of species overlap between the area of stations #11545 and 11542 and the calcareous reef area off the North Carolina coast suggests a definite faunal relationship between these two areas.

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TABLE 1. Station locality data.

Station #	Lat.	Long.	Depth	Substrate
E11542	32° 41.9'N	78° 23.5'W	130 meters	Fine sand
E11545	32° 41.8'N	78° 34.6'W	50 meters	Coarse sand
D.M. 0232	33° 28.5'N	77° 27.5'W	26-29 meters	Shell-sand

E=M/V Eastward; D.M.=M/V Dan Moore. Station #E11545 is approximately 8 miles west of #E11542.

TABLE 2. Species recorded from stations
#E11542 & E11545.

		STATION		
		E11545	E11542	
	STATION			ARCHITECTONIDAE
	E11545 E11542			<i>Heliacis bisulcatus</i>
				(Orbigny) R
				<i>Philippia krebsii</i>
				(Morch) R
FISSURELLIDAE				TURRITELLIDAE
<i>Diodora cayenensis</i>				<i>Turritella acropora</i>
(Lamarck) R				Dall C
ACMAEIDAE				<i>Turritella exoleta</i>
* <i>Acmaea</i> cf. <i>leucopleura</i>				(Linne) R
(Gmelin) R				CERTHIDAE
TROCHIDAE				<i>Litiopa melanostoma</i>
<i>Calliostoma pulchrum</i>				Rang R
(C. B. Adams) R				<i>Seila adamsi</i>
<i>Microgaza rotella</i>				(H. C. Lea) R
Dall C				TRIPHORIDAE
<i>Solariella lacunella</i>				<i>Trifora</i> sp. R
(Dall) A* R				EPITONIIDAE
<i>Solariella lamellosa</i>				<i>Epitonium novangliae</i>
(Verrill & Smith) C*				(Couthouy) R*
TURBINIDAE				EULIMIDAE
<i>Arene tricarinata</i>				<i>Niso aeglees</i>
(Stearns) R*				Bush A*
<i>Arene variabilis</i>				Unknown sp. R
(Dall) A*				CALYPTRAEIDAE
PHASIANELLIDAE				<i>Calyptrea centralis</i>
* <i>Tricola bella</i>				(Conrad) C*
(M. Smith) R				ERATOIDAE
<i>Tricola thalassicola</i>				<i>Erato maugeriae</i>
Robertson C				(Gray) R
VITRINELLIDAE				<i>Trivia antillarum</i>
<i>Aerotrema cistrionum</i>				Schilder R
(Dall) C				
Unknown sp.				

*before scientific name = possible range extension into South Carolina waters;

*following station information = live specimens found.

R = rare (1 specimen); C = common (2-9 specimens); A = abundant (10 or more specimens).

ATLANTIDAE

Atlanta peroni

Lesueur

C

NATICIDAE

Natica pusilla

Say

C

Polinices lacteus

(Goulding)

C*

Sigatica carolinensis

(Dall)

C

MURICIDAE

Murex leviculus

(Dall)

R

Murex rubidus

F. C. Baker

C*

Unknown sp.

R

COLUMBELLIDAE

**Anachis caltiglypta*

(Dall and Simpson)

C

**Anachis cf. petrii*

(Duclos)

A*

Anachis translirata

(Ravenel)

R

Mitrella lunata

(Say)

C

Mitrella raveneli

(Dall)

C

Psarostola minor

(C. B. Adams)

A*

BUCCINIDAE

Antillophos candei

(Orbigny)

C*

Cantharus tinctus

(Conrad)

R

Colubraria lanceolata

(Menke)

R

NASSARIDAE

Nassarius albus

(Say)

C*

Nassarius trivittatus

(Say)

C

OLIVIDAE

*?*Olivella bullula*

(Reeve)

A*

MARGINELLIDAE

Bullata ovuliformis

(Orbigny)

C*

Marginella aureocincta

Stearns

C

Prunum virginianum

Conrad

A*

MITRIDAE

Mitra hendersoni

(Rehder)

R

Uromitra wandoensis

(Holmes)

C

TURRIDAE

Ancistrosyrinx radiata

Dall

R

Bactrocythara cf. sp.

R

**Brachycythara barbarae*

Lyons

R

**Cerodrillia bealiana*

(Schwengel and McGinty)

C

**Cryoturris citronella*

(Dall) cf.

C

Cryoturris sp.

C

Daphnella morra

(Dall)

C

**Eubela cf. mcgintyi*

Schwengel

R

**Glyphostoma gabбии*

Dall

R

Inodrillia aepynota

(Dall)

C

**Ithyocythara lanceolata*

(C. B. Adams)

R

**Ithyocythara parkeri*

Abbott

C

**Ithyocythara psila*

(Bush)

R

Kurtziella cf. limonitella

(Dall)

C

Viridrillia cervina

Bartsch

A*

Unknown sp.

C

TEREBRIDAE

Terebra protexta

(Conrad)

C*

C

PYRAMIDELLIDAE

Turbonilla cf. dalli

(Bush)

A

**Turbonilla winkleyi*

Bartsch

R

Turbonilla sp. 1

R

Turbonilla sp. 2

R

Turbonilla sp. 3

R

Turbonilla sp. 4

C

ACTEONIDAE

Acteon punctostriatus

(C. B. Adams)

C

ACTEOCINIDAE

Cylichna cf. verrilli

(Dall)

C

Unknown sp.

C

SCAPHANDRIDAE

Scaphander watsoni

Dall

A*

PHILINIDAE

**Philine cf. planata*

Dall

R

**Philine tincta*

Verrill

R

BULLIDAE				PROPEAMUSIIDAE		
<i>Bulla occidentalis</i>				<i>Cyclopecten nanus</i>		
A. Adams	R			Verrill and Bush	C	
ATYIDAE				<i>Cyclopecten thalassinus</i>		
? <i>Atys</i> cf. <i>caribaea</i>				(Dall)		C
(Orbigny)	R			LIMIDAE		
RETUSIDAE				<i>Limatula setifera</i>		
<i>Retusa caelata</i>				Dall	C	
(Bush)		C		* <i>Limatula subauriculata</i>		
SIPHONODONTALIIDAE				Montagu		C
<i>Cadulus agassizii</i>				<i>Limca bronniana</i>		
Dall		C		(Dall)		C
<i>Cadulus carolinensis</i>				CHAMIDAE		
Bush		C		<i>Chama macerophylla</i>		
* <i>Cadulus minusculus</i>				Gmelin	R*	
Dall		C		ASTARTIDAE		
<i>Cadulus quadridentatus</i>				<i>Astarte nana</i>		
(Dall)	A*			Dall		C
DENTALIIDAE				* <i>Astarte smithii</i>		
<i>Dentalium laqueatum</i>				Dall		C
Verrill		A		CRASSATELLIDAE		
<i>Dentalium sowerbyi</i>				<i>Crassinella lunulata</i>		
Guilding	A*	A*		(Conrad)		C*
<i>Dentalium taphrium</i>				MESODESMATIDAE		
Dall	A*			<i>Ervilia concentrica</i>		
NUCULIDAE				(Holmes)		R
<i>Nucula crenulata</i>				TELLINIDAE		
A. Adams		A		<i>Macoma tenta</i>		
* <i>Nucula delphinodonta</i>				(Say)		C
Mighels		C*		<i>Tellina squamifera</i>		
NUCULANIDAE				Deshayes		A*
<i>Nuculana acuta</i>				<i>Tellina probrina</i>		
(Conrad)	C*	A*		Boss		C
<i>Nuculana aspecta</i>				<i>Tellina sybaritica</i>		
(Dall)		C		Dall		C
* <i>Yoldia sapotilla</i>				SCROBICULARIDAE		
(Gould)		R		<i>Abra lioica</i>		
SOLEMYIDAE				(Dall)		C*
* <i>Solemya</i> cf. <i>occidentalis</i>				SEMELIDAE		
(Deshayes)		R		<i>Semele bellastrata</i>		
ARCIDAE				(Conrad)		C*
<i>Arcopsis adamsi</i>				<i>Semele nuculoides</i>		
(E. H. Smith)	R*			(Conrad)		C*
GLYCYMERIDAE				<i>Semele purpurascens</i>		
<i>Tucetona pectinata</i>				(Gmelin)		C*
(Gmelin)	C*			VENERIDAE		
LIMOPSIDAE				<i>Chione cancellata mazyski</i>		
<i>Limopsis sulcata</i>				Dall		C*
Verrill and Bush		A*		<i>Chione latilirata</i>		
MYTILIDAE				Conrad		C*
<i>Amygdalum</i> cf. <i>papyria</i>				<i>Gouldia cerina</i>		
(Conrad)	C*			(C. B. Adams)		C*
* <i>Crenella</i> cf. <i>fragilis</i>				<i>Macrocallista maculata</i>		
(Verrill)		C		(Linne)		R*
PECTINIDAE				LUCINIDAE		
<i>Aequipecten muscosus</i>				<i>Lucina leucocyma</i>		
(Wood)		C		Dall		R*
<i>Chlamys benedicti</i>				<i>Phacoides filiosus</i>		
Verrill and Bush		C		Stimpson		C

UNGULINIDAE			
<i>Diplodonta punctata</i>			
(Say) (2 varieties)	C		
THYASIRIDAE			
* <i>Thyasira</i> cf. <i>gouldi</i>			
(Philippi)	C		
CARDITIDAE			
<i>Cardita dominguensis</i>			
Orbigny	C		
<i>Venericardia perplana</i>			
(Conrad)	R		
<i>Venericardia tridentata</i>			
(Say)	R*		
CORBULIDAE			
<i>Corbula dietziana</i>			
C. B. Adams	C*		
<i>Notocorbula operculata</i>			
(Philippi)	A*		
HIATELLIDAE			
<i>Hiatella artica</i>			
(Linne)	R		
PANDORIDAE			
<i>Pandora bushiana</i>			
Dall	C*		
<i>Pandora inflata</i>			
Boss and Merrill	C*		
LYONSIIDAE			
<i>Lyonsia hyalina</i>			
(Conrad)		R*	
THRACHIIDAE			
* <i>Cyathodonta semirugosa</i>			
(Reeve)		R	
POROMYIDAE			
<i>Poromya granulata</i>			
(Nyst & Westendorp)		C*	
VERTICORDIIDAE			
<i>Verticordia fisheriana</i>			
Dall		A*	
<i>Verticordia ornata</i>			
(Orbigny)		A*	
CUSPIDARIIDAE			
<i>Cardiomya costellata</i>			
(Deshayes)		C	
* <i>Cuspidaria granulata</i>			
(Dall)		C	
* <i>Cuspidaria turgida</i>			
Verrill and Bush		C	
Unknown sp.		R	

A REVISION OF THE MAINLAND SPECIES OF THE BULIMULID LAND SNAIL GENUS *RABDOTUS*

W. L. Pratt, Jr. *

Six species of the genus *Rabdotus* Albers, 1850 are known to inhabit the North American mainland and are treated in the present study. An indeterminate number of species inhabiting the Baja California peninsula and adjacent islands will be the subject of future research.

In the following checklist synonyms are given as they appear in Pilsbry (1946). *Bulimulus dealbatus pasonis* Pilsbry, 1902, for example, is cited as *Bulimulus pasonis*, following Pilsbry (1946); fuller synonymies as well as figures and descriptions of most of the taxa can be found in that work. For forms outside the range of Pilsbry (1946) the original description has been cited.

Subgenus *Rabdotus* (s. str.)

Rabdotus dealbatus dealbatus (Say, 1821)

(Synonymy: *Bulimulus d. dealbatus* (Say); *B. d. liquabilis* Reeve, 1848; *B. d. neomexicanus* Pilsbry, 1946; *B. d. ozarkensis* Pilsbry and Ferris, 1906).

Northeastern Mexico to eastern Kansas, east to

western Louisiana, Arkansas, and Missouri. Disjunct colonies in relict grasslands in southern Illinois, Kentucky, Mississippi, and Alabama. *R. d. neomexicanus* is simply a disjunct population in the mountains of southern New Mexico. Similar large forms occur at various localities in east central Texas.

Rabdotus dealbatus ragsdalei (Pilsbry, 1890)
(Synonymy: *Bulimulus dealbatus ragsdalei* Pilsbry).

A narrow zone west of the range of *R. d. dealbatus* in Texas, from the Red River to the Rio Grande.

Rabdotus dealbatus durangoanus (Martens, 1893)
(Synonymy: *Bulimulus durangoanus* Martens; *B. pasonis* Pilsbry, 1902; *B. novoleonis* Pilsbry, 1953).

Chihuahuan desert from Durango and Nuevo Leon to southern New Mexico in desert mountains. This is the taxon formerly treated under the name *Rabdotus pasonis* and regarded as a distinct species (Pratt, 1969). In the mountains of southern New Mexico and adjacent Texas it overlaps *R. d. dealbatus* without interbreeding, as noted by Pilsbry (1946: 19). However, it intergrades with *R. d. ragsdalei* in Terrell County, Texas and with *R. d. dealbatus* on the eastern slope of the Sierra Madre Oriental in western

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Nuevo Leon and eastern Coahuila. The type of *Bulimulus novoleonis* Pilsbry is a normal specimen of this taxon. *Bulimulus durangoanus* Martens is also based on this widespread Chihuahuan desert form and by the law of priority Marten's name must replace the more familiar *Bulimulus pasonis* of Pilsbry.

Rabdotus alternatus (Say, 1830)

(Synonyms: *Bulimulus alternatus alternatus* (Say); *B. a. mariae* (Albers, 1850); *B. a. hesperius* Pilsbry and Ferriss, 1924; *B. schiedeanus* (Pfeiffer, 1841); *B. patriarcha* (Binney, 1858), for figure and description see Binney, 1885.

Val Verde, Bexar, and Jackson Counties, Texas, south to southern Tamaulipas and San Luis Potosi; up valley of Rio Grande to above Presidio, Texas. Scattered disjunct colonies in Chihuahuan Desert of Chihuahua, Coahuila, and northern Durango, and in the rain shadow of Pico Orizaba in eastern Puebla and adjacent Vera Cruz and Oaxaca. Highly variable. The Chihuahuan desert and Puebla populations seem to be subspecifically distinct from those of south Texas and northeastern Mexico. The name *Rabdotus alternatus hesperius* (Pilsbry and Ferriss) is available for the Chihuahuan desert populations, from the Pecos River, Texas, westward and was also applied by Pratt (1969). The name *Bulimulus schiedeanus* (Pfeiffer) was first applied to these populations by Martens (1893), followed by Pilsbry (1946) and in part by Hubricht (1960) and Pratt (1969). It seems preferable, however, to restrict that name to the population in the Pico Orizaba rain shadow, which was considered typical by Martens (1893), which then becomes *Rabdotus alternatus schiedeanus* (Pfeiffer). In view of the protean variability of the species and in the absence of adequate material from Mexico it seems the wisest course to minimize the use of trinomen for the present.

Rabdotus mooreanus mooreanus (Pfeiffer, 1868)

(Synonymy: *Bulimulus dealbatus mooreanus* (Pfeiffer); *B. schiedeanus pecosensis* Pilsbry and Ferriss., 1906; *B. mooreanus pecosensis* P. & F., Hubricht, 1960).

Texas, from Pecos River to border of pine-hardwood forests, Webb, Duval, and San Patricio Counties, north to Red River. Disjunct colonies in Oklahoma, Kansas, Arkansas, and Missouri. As noted by Hubricht (1960) the southern limit of *R. mooreanus* seems to be determined by competition with *R. alternatus*. Although relict colonies of *R. mooreanus* occur within the range of *R. alternatus*, the two species never occur together at the same locality.

Rabdotus mooreanus jonesi (Clench, 1937).

(Synonymy: *Bulimulus dealbatus jonesi* Clench).

Relict grasslands on the Selma chalk of west central Alabama and adjacent Mississippi. Hubricht (in litt.) has considered these populations to be introduced, but the character combination of *R. m. jonesi* is not matched by any material from west of

the Mississippi River. It seems probable that the Alabama and Mississippi populations are xerothermal relicts, as are the grasslands in which they occur.

Rabdotus nigromontanus (Dall, 1897)

(Synonymy: *Bulimulus nigromontanus* Dall; *B. sonorensis* Pilsbry, 1928).

Tumacacori Mountains of Santa Cruz County, Arizona south to Carbo, Sonora. The type material of *Bulimulus sonorensis* is not distinguishable from *R. nigromontanus*.

Subgenus *Hannarabdotus* Emerson and Jacobson, 1964.

Rabdotus pilsbryi (Ferriss, 1925)

(Synonymy: *Bulimulus pilsbryi* Ferriss).

Eastern Big Bend region of Texas and isolated localities near Jimenez, Chihuahua and Rodeo, Durango. Probably in desert mountains through much of the Chihuahuan desert.

Rabdotus baileyi (Dall, 1893)

(Synonymy: *Bulimulus baileyi* Dall).

Sonoran Desert of Mexico from the Rio Magdalena, Sonora to northern Sinaloa. A disjunct (?) occurrence at Mazatlan.

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TAXONOMIC PROBLEMS WITH INDO-PACIFIC *TRICOLIA* (PHASIANELLIDAE)

Robert Robertson*

This is a progress report on a monograph of the Phasianellidae for "Indo-Pacific Mollusca." Eight Indo-West-Pacific species of *Tricolia* Risso, s. str., are being recognized, and three species in the subgenus *Hiloea* Pilsbry. Singled out for discussion here are the relationships between a pair of species of *Tricolia*, s. str., and the problems of categorizing species of *Hiloea*.

Tricolia indica Winckworth ranges from western India to the Strait of Malacca and has a shell closely resembling that of a new species I am describing from East Africa (Kenya to the Somali Republic). These zoogeographic neighbors are the same shape and size and have similar sculpture. They differ in the coarseness of their sculpture, in their colors and patterns, in the presence or absence of an umbilical chink, in the thickness of the shell, and in the size of the first whorl. The two species are the only ones known in the family to have posterior median projections on the jaws. Initially, I was inclined to rank the new taxon as a subspecies of *T. indica*. Then I discovered that their radulae differ greatly. Relative to shell size, the radula of *T. indica* is much smaller than that of *T. n.sp.*, has much smaller teeth, and has fewer marginals in much more curved and broadly overlapped transverse rows. *T. indica* has the innermost pair of laterals fused into a pseudocentral, and only three pairs of unfused laterals remain. The outermost marginals are widened, fused, and spinose. No other phasianellid radula is similar. I could name a new monotypic genus or subgenus based on *T. indica*, but I believe that such action would be wrong. Excepting the radula, the evidence points to *T. indica* being closely related to *T. n.sp.* There is a striking difference in the habitat of the two species. *T. n.sp.* lives among algae, as is usual for phasianellids. *T. indica*, on the other hand, lives on a siliceous sand bottom where there are no macroscopic plants and where the water is opaque with suspended detritus. I have collected the species off Cochin, India, and this habitat is unlike that of any other phasianellid. I suggest that *T. indica* has evolved a special, perhaps carnivorous diet and as a consequence has a special radula. Other data show that phasianellid radulae are more evolutionarily plastic than are the shells. I

conclude that genera and subgenera should not be distinguished in any group of gastropods on radular characters alone. Radula differences should be considered in the context of the total biology of the animals.

The subgenus *Hiloea* is endemic to the Indo-West-Pacific, and is the predominant group of minute phasianellids in the area. I have had available for study more than 5,800 specimens. Their sexually dimorphic shells and radulae have already been discussed in a preliminary paper (1971, A.M.U. Ann. Rept. for 1970, pp. 75-78, 2 figs.). Provisionally I am recognizing three latitudinally separated, allopatric species: *Tricolia (Hiloea) megastoma* (Pilsbry) from Japan, *T. (H.) variabilis* (Pease) from most of the tropical Indo-West-Pacific, and *T. (H.) virgo* (Angas) from New South Wales, Australia. The only consistent differences noted between these is that the two subtropical species have larger first whorls of both the shell and the operculum; also, their periostracums are thicker. These characters could be climatically induced, and they may be shown to intergrade clinally. The Japanese species attains larger shell sizes than either of the others, but the size disparities between populations of *T. (H.) variabilis* are far greater. The Japanese species also has more pairs of marginal radular teeth, but the numbers of these correlate with shell size throughout the subgenus. Differences between populations of *T. (H.) variabilis* are more extreme than those supposedly differentiating the species. The following characters are shown to vary geographically:

1. The numbers of spiral threads or cords above the suture on the early teleoconch whorls
2. The percentages of shells that predominantly are spirally dotted or spirally lined
3. The maximum attained shell sizes
4. The numbers of pairs of marginal radular teeth in adults
5. The cusping of the pseudocentral radular teeth in adults

Excepting characters 3 and 4, each shows a wholly different pattern of geographic variation. Thus there is a complex geographic mosaic of characters. A pelagic larval stage is suppressed, and the restriction of gene flow between populations helps to explain the origin and maintenance of the geographic polymorphism. Despite the polymorphism, there is no evidence for genetically definable subspecies. Such

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taxa either would have to be based on a single character, or each population in the mosaic would have to be considered distinct. The whole subgenus

may be one genetic continuum, in which case it would be far the most polymorphic marine gastropod species known.

VERTICAL AND SEASONAL DISTRIBUTION OF PELAGIC CEPHALOPODS IN THE MEDITERRANEAN SEA. PRELIMINARY REPORT.

Clyde F. E. Roper*

Although benthic and neritic cephalopods of the Mediterranean Sea have been studied since Aristotle first observed *Octopus* behavior, the pelagic forms have received very little attention. The Mediterranean Biological Studies Program of the Smithsonian Institution, an outgrowth of the Ocean Acre Program in the Sargasso Sea (see Gibbs and Roper, 1970; Gibbs *et al.*, 1971), provided the opportunity to study in detail the midwater macrofauna with particular emphasis on diel vertical distribution of species and their seasonal and geographical variation in occurrence and abundance. The precision and detail required for collecting specimens for such a study was achieved through use of a net-closing device, the discrete-depth cod-end sampler, rigged to a 3 m Isaacs-Kidd Midwater Trawl (IKMT) (Aron *et al.*, 1964). This instrument permits collecting of three replicate samples at any desired depth during a single lowering of the trawl. The closing devices are actuated from shipboard through use of a multiconductor towing warp; monitoring of depth of net and ambient temperature permits precise placement and control of the fishing depth of the trawl during each tow.

Five localities were selected as collecting stations (Figure 1) and were sampled during the summer of 1970 and the winter of 1972. The sampling regime consisted of IKMT discrete-depth tows both day and night at 50, 100, 150, 200, 300, 400, 500, 600, 800 and 1000 meters and neuston tows at the surface. Sampling at all depths for all stations was not possible to complete because of lack of time. Station I was not sampled in winter. Station data are presented elsewhere (Gibbs, 1972).

During the two cruises a total of 591 cephalopods, representing 21 species, was captured: 362 specimens representing 15 species in summer; 229 specimens representing 17 species in winter. A total of 760.2 hours was spent in trawling; trawling time was about equally divided between the two cruises (summer: 368.1 hrs; winter: 392.1 hrs). All species captured were members of the North Atlantic fauna, so no endemic component of the Mediterranean fauna is represented. A preliminary report on the cephalopods

taken during the summer cruise has appeared (Roper, 1972).

Limited space precludes a detailed report of all species here so the results for four species will be discussed as examples of the types of vertical and seasonal distributions exhibited by pelagic cephalopods in the Mediterranean. A more comprehensive account will be published elsewhere. All day and night closing-net and neuston net captures have been standardized for analysis of vertical distribution to number of specimens captured per hour of trawling (spec./hr) at any given depth. In the consideration of vertical distribution, specimens captured within 1 hour before or after sunrise or sunset were eliminated because these are the primary hours during which active vertical movements take place. In order to access the seasonal abundance and distribution all captures at each station were analyzed, e.g. discrete, oblique, open-net, neuston net and twilight-captured specimens.

SUMMARY OF RESULTS

1. Fourteen discrete specimens of *Heteroteuthis dispar*, a small sepiolid squid, were captured in summer during daytime over a range of 150-500 m at an average rate of capture of 1.7 (range 1.0-7.0) specimens per hour of trawling; 64% of the sample population was concentrated in a narrow band at 400-425 m. At night an average of 2.5 (1.0-5.3) spec./hr (30 discrete specimens) was captured between 25 and 300 m, with 81% of the sample concentrated at 25-100 m. Therefore, in the summer *H. dispar* in the Mediterranean appears to undergo a diel vertical shift where the "center" of the population moves vertically about 350 m during the morning and evening crepuscular periods. The vertical range is broad and a 150 m overlap of the day and night distributions occurs. In winter two specimens (average of 0.8 (0.7-1.0) spec./hr) were captured in the closing net during the day at 500 and 525 m. At night an average of 3.8 (1.0-6.6) spec./hr (8 specimens) was taken at 25-200 m, 90% of them at 25-100 m. Although data are less complete for winter it seems likely that a vertical shift similar to that of summer occurs. An average of 1.2 spec./hr (3 spec., one from an open net) was caught in less than 75 m in winter, while 2.7 spec./hr (29 spec.) were captured in less than 75 m in the summer.

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The determination of seasonal occurrence and relative abundance at each station utilizes all specimens captured by all gear, the result recorded as total number of specimens per hour of trawling (tot. spec./hr). The results are presented in Table I.

H. dispar was absent from station 1 in summer but occurred in about equal numbers at stations 2 and 3. While the species appears to be absent from station 4, fishing effort there may have been too low to pick up specimens in low abundance. Station 5, with greater effort, yielded a low rate of abundance. In winter *H. dispar* was entirely absent from stations 2 and 3 (station 1 was not sampled) but was present in equal abundance at stations 4 and 5. *H. dispar* was significantly more abundant at station 5 in winter than in summer. The absence of *H. dispar* in the northern Balearic (station 2) and Tyrrhenian (station 3) Seas in winter and in the Ionian (station 4) and Levantine (station 5) Seas in summer may indicate a seasonal shift of the population toward the eastern basins in wintertime.

2. *Pyroteuthis margaritifera*, a known strong diel vertical migrator, was represented by 22 specimens captured in the closing net. In the summer during the day an average of 1.0 (1.0-1.0) specimens per hour (4 specimens) was captured between 400 and 600 m, with 50% concentrated at 400 m. At night an average of 1.4 spec./hr (1.0-2.0) (8 specimens) was captured between 50 and 250 m with 75% of the sample population concentrated at 150-200 m. In summertime a strong diel migration is indicated that may extend over a vertical distance of 150-550 m. In winter an average of 4.0 spec./hr (4.0) (4 specimens) was captured at 400 m during daytime, while at night an average of 1.3 spec./hr (1.0-2.0) (4 specimens) was taken at 75-375 m, with 50% at 75 m. Although a diel vertical migration does occur during winter, too few data points are available for a complete description to be made.

P. margaritifera was absent from stations 1, 2, and 4 during summer; it was present at stations 3 and 5 in concentrations of 0.13 and 0.03 total specimens per hour respectively. Although the greatest trawling effort was at stations 3 and 5, stations 1 and 2 were adequately sampled; very little trawling was done at station 4, so the apparent absence of *P. margaritifera* may not be real. In winter, no specimens of *P. margaritifera* were captured at stations 2 and 3, but the species did occur in about equal abundance at stations 4 and 5. *P. margaritifera* appears to exhibit an eastward shift of the population in winter, leaving the summertime center of abundance in the Tyrrhenian Sea (station 3) entirely devoid of specimens in winter. The relative abundance of *P. margaritifera* in winter is about three-fifths that of summer.

3. A total of 31 specimens of *Ctenopteryx sicula* was captured in closing nets, 23 in summer and 8 in winter. In summertime during the day 7 specimens were captured at an average rate of 1.7 specimens per

hour (1.0-3.0) over a range of 100-150 m. At night 8 specimens were taken at an average of 2.7 spec./hr (1.0-4.0) at 50-150 m, with 88% taken at 50-100 m. The 8 additional specimens captured during twilight were caught at an average of 3.2 spec./hr (1.0-6.0) at 25-100 m with the center of abundance at 50-100 m. In winter an average of 2.1 (1.0-4.0) spec./hr (8 specimens) was captured at night at 50-100 m with a peak of abundance (75%) at 50-75 m. No captures were made during the day. At present it is uncertain if *C. sicula* is a vertical migrator, because, while the data show an apparent limited ascent at night to 25-100 m from 100-150 m, daytime sampling at less than 100 m was minimal.

C. sicula was present in equally low abundance in the summer at stations 1 and 2, while a 10-fold increase occurred at station 3, the center of abundance in summertime (Table I). No specimens were taken at stations 4 and 5. In winter the center of abundance occurred at station 4 where captures were slightly greater than the summertime abundance at station 3. No material was taken at station 2; the catches at stations 3 and 5 were negligible. Therefore, the center of abundance of *C. sicula* appears to shift from the Tyrrhenian Sea in the summer eastward to the Ionian Sea in winter.

4. *Onychoteuthis banksi*, the most abundant cephalopod captured during the Mediterranean studies, was also the only cephalopod that was captured at every station both summer and winter. A total of 104 specimens was captured in the closing net, 84 in the summer and 20 in the winter. In the summer during the day an average rate of capture of 1.7 specimens per hour (0.8-5.0) was made between 50 and 800 m; 46% of the captures was concentrated at 50-100 m and 38% at 750 m. At night an average catch of 4.5 spec./hr (0.8-24.0) was attained between 0 and 300 m, with only one capture at 300 m and the rest at 100 m or less; 49% of the captures occurred at 50 m and 37% at 100 m. In the winter an average of 1.2 spec./hr (1.0-1.3) was captured during the day, one specimen each at 75 m and 375 m. At night during the winter an average of 4.1 spec./hr (1.0-12.0) was taken between 0 m and 150 m; 83% of the captures was concentrated at 25-75 m (50% at 25 m).

O. banksi clearly has a broad vertical range, particularly during the daytime (summer), but heaviest concentrations occur in the upper 100 m both day and night. The range is more restricted at night when nearly the entire population occurs at 25-100 m. As strong, active swimmers the larger juveniles and the adults are able to make occasional excursions to depths of 600-800 m during the day, apparently returning toward the surface waters at night. Winter captures, less numerous than those of summer, occur over a more restricted range of depths (0 - 375 m).

O. banksi was present at all 5 stations during the summer, with maximum abundance at station 3,

followed by station 2; it was least abundant at station 1 (Table I). In winter the center of abundance of the sample population occurred at station 4 where the species was three times more abundant than at station 3. Captures at stations 2 and 5 were very low.

O. banksi, therefore, is distributed throughout the area of study both summer and winter, but is concentrated in the central basins. The site of greatest abundance occurs in the Tyrrhenian Sea (station 3) in summer and shifts eastward to the Ionian Sea (station 4) in winter.

SUMMARY

The cephalopods collected during the Mediterranean Biological Studies Program exhibit several different types of diel vertical distributions, four of which are: 1) *Heteroteuthis dispar* shifts up toward the surface at night but retains a significant zone of overlap of day and night distributions. 2) *Pyroteuthis margaritifera* exhibits strong diel vertical movements of at least 200-500 m in extent with no overlap. 3) *Onychoteuthis banksi* is distributed

broadly throughout the water column to about 800 m but is concentrated in the upper 100 m. 4) *Ctenopteryx sicula* is very restricted in vertical range, limited to the upper 150 m.

Seasonal differences also occur. In general, relative abundance of a species is considerably lower in winter than in summer. A general trend exists for the displacement of the bulk of the population of each species toward the eastern basins in wintertime. Station 3 was most productive in the summer, while station 4 was most productive in the winter.

Acknowledgements

I wish to thank the following for support during the Mediterranean Biological Studies Program: biologists of the Smithsonian Institution, University of Rhode Island, Naval Oceanographic Office, (Washington) and Underwater Systems Center (New London); Office of Naval Research (Contract No. N00014-67-A-399-0007); officers and crew of the research vessels TRIDENT and SANDS. I am especially grateful to M. J. Sweeney and R. D. Gattton for preparing specimens and data for analysis.

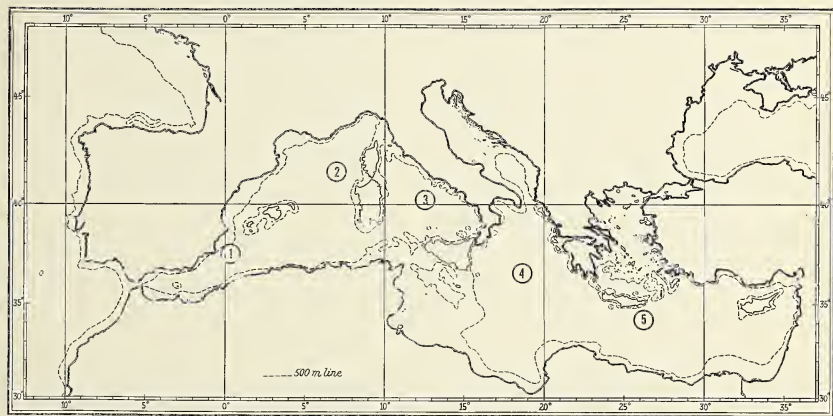


Figure 1. Location of collecting stations in the Mediterranean Sea.

TABLE I. Total number of specimens captured per hour of trawling (all sampling devices included).

Station No.	<i>H. dispar</i>	<i>P. margaritifera</i>	<i>O. banksi</i>	<i>C. sicula</i>
Summer				
1.	0.00	0.00	0.06	0.02
2.	0.36	0.00	0.36	0.02
3.	0.34	0.13	0.52	0.20
4.	0.00	0.00	0.26	0.00
5.	0.02	0.03	0.15	0.00
TOTAL AVERAGE	0.21	0.05	0.32	0.07
Winter				
1.	Not Sampled			
2.	0.00	0.00	0.00+	0.00
3.	0.00	0.00	0.13	0.01
4.	0.11	0.11	0.42	0.21
5.	0.11	0.09	0.02	0.00+
TOTAL AVERAGE	0.04	0.03	0.07	0.02

+Fewer than 0.01 spec./hr.

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STUDIES ON ASCENSION ISLAND MARINE MOLLUSKS

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Ascension in the tropical mid-South Atlantic is a young island compared to most nearby land masses. It is fairly well established that Ascension is of Pleistocene origin, and various estimates of its age range from 10,000 to over one million years with volcanic activity probably having taken place in the past few hundred years (Wilson, 1963; Duffey, 1964; Atkins, *et al.*, 1964). The nearest land mass, the island of St. Helena, is considerably older, probably dating from the Miocene. The geological youth of

Ascension makes it of interest faunistically. The marine shallow water invertebrates living there now must have arrived during the elapsed time since the emergence of the island's cooled volcanic substance. It is, therefore, a kind of laboratory on which one can study the effects of dispersal of marine animals by currents and other means and also the effects of isolation as they may be expressed in the evolution of distinct island species.

The mollusks of Ascension were first well enumerated by E. A. Smith (1890b) in a report which listed 42 species of which 9 were from deep water and not properly characterized as shallow water species. Little further has been written on the island

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except for the reports of Stearns (1892) and Packer (1968) which added virtually no new species to the fauna. Ekman (1953) practically ignored Ascension in his remarks on Atlantic island zoogeography because of lack of information. In recent years the island has become more accessible. During World War II it was a refueling stop for transoceanic flights and most recently it has done service as a missile tracking station. Some of its recent human inhabitants have collected marine animals, including mollusks, and the collection of one such person, Mrs. Kay Hutchfield, was sent to me for identification. In 1971 Dr. R. B. Manning visited Ascension and made an intensive collection of shallow water marine invertebrates. These collections have been studied with some rather interesting results.

The information from the new collections of mollusks, when added to the previous records, results in a 100 percent increase in the number of species inhabiting Ascension (84: 42). The question immediately arises: "Have these additional species arrived since the initial census by Smith?". This cannot be answered definitely, of course, although it is possible that some of them are new arrivals and that this influx will continue barring some catastrophic occurrence on the island. At least part of the increase may be due to more complete collections having been made more recently. A rounding of the figures of known species when compared with the supposed geologic age of the island, 100: 1,000,000 respectively, yields a possible arrival rate for new immigrants of one each 10,000 years! If the age of the island is even twice that, it would mean one new species each 20,000 years, a really insignificant change when the totality of geologic time is imagined.

Most of the mollusk species now living on Ascension originated elsewhere, that is they are generally considered to be inhabitants either of western Atlantic, eastern Atlantic, or of both areas, i.e., amphi-Atlantic. In a smaller number of cases they are inhabitants in addition of another faunal area, i.e., they are pantropical species. In a very few cases, they are endemic, apparently having evolved on the island, possibly from an ancestral form now extinct.

In the case of marine invertebrates having planktonic larvae it is generally conceded that ocean currents may transport them over varying distances and in this way they have achieved their present distributions. Other means are needed to explain the distributions of non-planktonic forms. The suggestions have been made that they may rely on wind and even bird transport or may be carried on floating objects. Man is often implicated. A recently proposed explanation becomes involved with continental drift (Chace and Manning, 1972). In the present case no new explanation for the transport of species will be attempted. It is here considered of sufficient interest that most of the various species have originated elsewhere and that by some means they have arrived at Ascension. The recent papers of

Scheltema (1968, 1971a, b) in which the North Atlantic drift, the westward-flowing North and South Equatorial currents, the eastward-flowing Equatorial counter current and undercurrent are discussed are considered to be especially pertinent in explaining Atlantic ocean distributions.

An analysis of the geographic origins of the marine mollusks of Ascension indicates that about 23% of them are derived from the western Atlantic, 27% from the eastern Atlantic, 21% occur in both eastern and western Atlantic, 10% are pantropical, while only about 10% are endemic.¹ When these statistics for Ascension are compared to the information known for St. Helena (Smith 1890a) an interesting correlation becomes apparent. Approximately 14% of the marine mollusks of St. Helena are from the west and 14% from the east; 5% occur in both east and west; 16% are pantropical; and 51% are endemic. It is significant to note that faunal relationships of the two mid-Atlantic islands are roughly comparable as to the source of their faunas, but there is a major discrepancy in the numbers of endemic species: 51% of the fauna being endemic on St. Helena and only 7% on Ascension. The reason for this discrepancy may lie in the comparative ages of the two islands, that of St. Helena being of the order of 20 million years, while Ascension is only 1 to 2 million.

This result, although still rather tentative, supports what probably would be predicted concerning endemicity in the two islands based on their ages. If isolation over a long time period allows genetic differentiation and with it speciation, it should be more evident on St. Helena than it is on Ascension and the figures substantiate this. Regarding the origin of the fauna of Ascension (and also of St. Helena which probably is comparable) the species seem not to have arrived predominantly from either east or west, but rather equally from both directions and include immigrants from other faunal zones as well. This lends credence to the belief that given sufficient time and a vehicle such as the ocean currents, species will colonize any area they can reach that is ecologically acceptable.

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SNAIL-RELATED PUBLIC HEALTH PROBLEMS IN THE MEKONG

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Snail biology appears to be more important in large dam developments in the Mekong than most planners realize. This is well illustrated in the region of the recently completed Uboratana (also called Nam Pong) Dam of Northeast Thailand. A few of the snail-related health problems are cited to emphasize the need in the planning stages for better consideration of the feasibility of such dam-building projects.

To provide more protein in the native diet a small fish-pond had been built near Khon Kaen, but it was avoided for fishing when the non-human schistosome, *Schistosoma spindale*, developed to troublesome proportions. The pond was being used for immersing the water buffalo which, in turn, left behind the parasite eggs that hatched to infect the pond snails, *Indoplanorbis exustis*, living there in large numbers. One of the men to whom we spoke about this problem rolled up his pants and displayed a severe case of schistosoma dermatitis. While the conditions have not as yet been studied, non-human bird schistosomes, also, will undoubtedly prove to be a nuisance in this region.

The water from this same pond was used to soak jute, or "kenaf" as it is called locally. The stalks of the plant are allowed to rot and soften and the fiber is then stripped to make the jute. There was no evidence that the women doing this work were infected, but the rotting process was a source of pollution to the local streams.

Another small pond in this same region contained many *Pila* (ampullarid) snails used as a source of protein. Unfortunately, those snails were often not properly cooked with the result that many of the local people suffered from brain lesions. The snails become infected with the rat lung worm — a

nematode called *Angiostrongylus cantonensis*; the larvae of the parasite travel through the brain tissues of the definitive hosts enroute to the lungs. It was of interest to find that, while the Thai people in that northeast Thailand region were seriously infected, the people in the vicinity of the Prek Thnot Dam southwest of Phnom Penh (Cambodia) cook *Pila* snails thoroughly and the incidence of brain lesions is far less.

Another snail-borne disease of serious proportions and common to persons living in the neighborhood of the Uboratana Dam is opisthorchiasis — a human liver disease acquired from eating improperly cooked fish. People living in the region of the impoundment were paid for their flooded land but no provision was made for re-housing them. They settled in a filthy village not far from the dam. *Parafossarulus* (bythinid) snails inhabiting the margin of that man-made lake are infected by miracidia from the human wastes and these people are in turn infected when they eat poorly cooked fish. Human infections there are reported to be near one hundred percent!

Perhaps a more serious threat to health in the lower Mekong is the recently discovered strain of *Schistosoma japonicum* carried by a snail (*Lithoglyphopsis aperta*) and representing a genus not hitherto suspected of carrying Oriental schistosomiasis (blood fluke). In a floating village made up of Vietnamese people living on the river opposite Cratie, Cambodia, the incidence was known (and reported informally by authorities in the World Health Organization) as 50 percent. No one can predict how prevalent this disease may become when the many dams projected for that region are constructed. This problem has recently been discussed in a short paper with the title: *Dam(n) Large Rivers — Then What?* (*The Biologist*, 55: 39-35, 1973).

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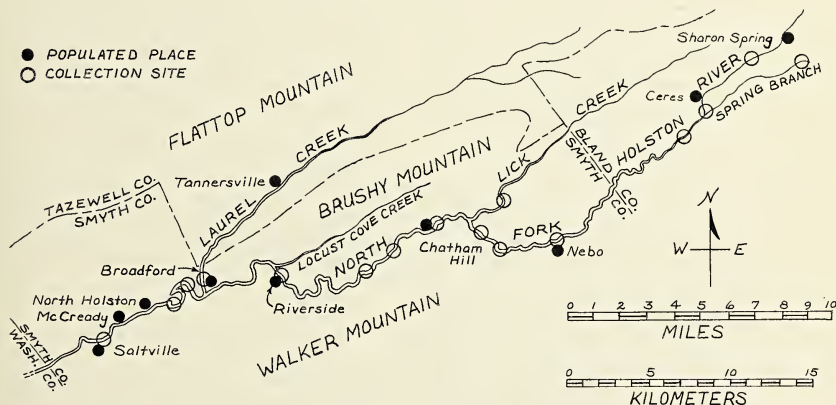
THE PLEUROCERIDAE AND UNIONIDAE OF THE NORTH FORK HOLSTON RIVER ABOVE SALTVILLE, VIRGINIA

David H. Stansbery* and William J. Clench*

The Ridge and Valley Province of the Southern Appalachians in the western part of the state of Virginia is well named since it is characterized by parallel mountain ranges or ridges alternating with deep stream-occupied valleys. The North Fork Holston River, flowing southwest, shares such a valley with Walker Creek, which flows northeast as a tributary of the ancient New River system. The headwaters of these two master streams interdigitate here on the valley floor and approach each other within a few hundred feet. The composition of the molluscan faunas of these two streams is strikingly dissimilar in spite of the fact that both are small, cool, swift, mountain headwaters and both are part of the Ohio River drainage system. This paper is the result of an effort to determine the composition and

distribution of the pleurocerid and unionid mollusks living today in the North Fork Holston River above Saltville, Virginia, and what changes may have occurred in this fauna since the reports of Say (1825), Adams (1915) and Ortmann (1918). Publications on the mollusks of the Holston River by Lewis (1871), Boepple and Coker (1912) and Remington and Clench (1925) refer to the fauna of the Holston proper far downstream below Saltville and below the confluence of the North, Middle and South Forks of the river. There is a need to study the entire length of the North Fork in some detail in order to document and interpret past and future changes in the fauna. This study is a direct outgrowth of our work on the fauna at Saltville in 1968 (Stansbery 1972).

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NORTH FORK HOLSTON RIVER ABOVE SALTVILLE, VIRGINIA

The North Fork Holston River rises from several springs in the vicinity of Sharon Springs, Virginia, and follows a tortuous course SW about 30 air miles down the valley between Brushy and Walker Mountains to Saltville, Virginia. The Karst topography of the valley floor reveals the presence of soluble limestone which may well contribute to the well-being of the mollusk fauna.

Thomas Say (1825) noted that his specimens, the types, of *Fusus fluviatilis* (now *Io fluviatilis*), were collected by Vanuxem "on the north fork of the Holston River, near the confluence of a brook of salt water". This site has been generally assumed to be at or in the vicinity of Saltville. Adams (1915:18) found *Io fluviatilis* present at Saltville "From above the 'alkali works' upstream for 2 or 3 miles" on 20 August 1900. He failed to find *Io* downstream from the chemical plant's effluent. Other pleurocerids were not mentioned.

When Ortmann (1918) collected the North Fork Holston River (17 September 1912) in his study of the naiades of the upper Tennessee River drainage, he worked no further upstream than Saltville. His material from this site combined with that collected there by an O. A. Peterson (20 June 1917) (Ortmann 1918:608) totaled 16 species of unionids. Pleurocerids were not included in the study.

A search of the Saltville site above the polluting outfall in 1968 yielded specimens of 9 of the unionids recorded by previous workers plus 2 additional unionids and 2 pleurocerid species not previously recorded (Stansbery 1972). No trace of *Io fluviatilis* was found. The closing of the Olin Corporation plant at Saltville in 1972 (Newcombe and Villet, 1971:36) brought about conditions favoring the possible recovery and repopulation of the North Fork below Saltville. Since the reseeded of the river may well depend in large part upon the populations now living upstream, it has seemed desirable to do this study.

Collections of bivalves and gastropods were made along the main stem at each bridge or reasonable point of access in 1968 or 1972 or both. The three main tributaries, Spring Branch, Lick Creek, and Laurel Creek were each sampled once. A total of 16 sites were studied as indicated in the table giving a mean sampling frequency of one collection for each 4 or 5 river miles on the North Fork proper. All specimens collected were either living mollusks or fresh shells indicating the presence of a living population. We found no direct evidence, "bones" or sub-fossil material, indicating the previous existence of *Io fluviatilis* or any other fluviatile mollusk not presently living in this part of the Holston today.

The results, when arranged in tabular form, demonstrate an expected increase in species diversity going downstream towards Saltville. This varied from 0 at the uppermost site to a total of 20 species at Saltville. The frequency of occurrence and range of distribution within the main stem were calculated for

each species found. *Spirodon patula*, *Villosa iris nebulosa*, and *Villosa vanuxemi* had the greatest range, being found at all but the uppermost site. The least common species were *Goniobasis simplex*, found only at two of the uppermost sites and *Strophitus undulatus shaefferianus*, *Lasmigona costata*, *Ptychobranchus fasciolaris*, and *Lampsilis ventricosa*, all of which were restricted to two sites at or near Saltville. None of the typical headwater species "dropped out" going downstream, except *Goniobasis simplex*, indicating that the entire North Fork above Saltville might well be termed "headwaters". Since all but one of the naiad species previously recorded from Saltville may still be found there and two species have recently been added to the list, we must infer that the pollution responsible for the destruction of most or all of the molluscan fauna below Saltville has had little or no known effect on the fauna above that point. If any unionids living above Saltville were dependent on factors downstream, such as host fishes, these species must have either been destroyed before the earliest collections were made, thus leaving no record, or have somehow escaped detection by all studies in the area to date.

If Ortmann's reason for not seeking naiades above Saltville was the belief that no additional species (headwater species) were to be found there, we are confident that his reasoning was correct.

We are at a loss to explain the absence of *Io fluviatilis* from its former habitat "above the 'alkali works' upstream for 2 or 3 miles". While possibilities would include such modern contaminants as detergents and pesticides, we can only conclude that whatever factor(s) was responsible did not eliminate the naiades or the other pleurocerid species present. To demonstrate, with reasonable certainty, the presence or absence of a species, especially a rare species, from an area of free-flowing stream is a task frequently fraught with many difficulties but these are apt to be relatively minor problems, indeed, when compared to those one may encounter in attempting to discern the reasons for such presence or absence. It is our hope that this summary will provide a base from which the recovery of the mollusk fauna of the North Fork Holston River below Saltville can be measured.

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SPECIES RECORDED

FAMILY UNIONIDAE

Subfamily Anodontinae

Strophitus undulatus stuefferianus (Lea, 1852).*Alasmidonta marginata* Say, 1818.*Alasmidonta viridis* (Rafinesque, 1820).*Pegias fabula* (Lea, 1836).*Lasimigona costata* (Rafinesque, 1820).

Subfamily Amblesimae

Fusconala edgariana (Lea, 1840).*Fusconala barnesiana* (Lea, 1838).*Lexingtonia dolabelloides* (Lea, 1840).*Pleurobema ouiforme* (Conrad, 1834).

Subfamily Lampsilinae

Pychobranchus fasciolaris (Rafinesque, 1820).*Pychobranchus subtentum* (Say, 1825).*Actinonassa pectorosa* (Conrad, 1834).*Toxolasma l. lividus* (Rafinesque, 1831).*Medionidus contractus* (Lea, 1834).*Villosa iris nebulosa* (Conrad, 1834).*Villosa vanuxemi* (Lea, 1834).*Lampsilis ventricosa* (Barnes, 1823).*Lampsilis fasciola* Rafinesque, 1820

Total Naiad Species Recorded

FAMILY PLEURO CERIDAE

Pleurocera uncialis (Haldeman, 1841).*Goniobasis simplex* (Say, 1825).*Spirodon patula* (Anthony, 1860).*Anculosa subgibbosa* (Say, 1825).*Io fluviatilis* (Say, 1825).

Total Pleurocerid Species Recorded

x = species present

+ = species added

- = species removed

s = same

Species	3 mi NE Ceres, 1968	Ceres, 1971	1.7 mi SW Ceres, 1971	Nebo, 1971	1.9 mi WSW Nebo, 1971	1.9 mi ESE Chatham Hill, 1971	Chatham Hill, 1968	1.5 mi SW Chatham Hill, 1971	2.8 mi SW Chatham Hill, 1971	2.5 mi E Broadford, 1968, 1971	1.0 mi SW Broadford, 1971	4.3 mi NE Saltville, 1968	Saltville, 1968, 1971	Saltville, 1912 & 1917	Saltville, 1900	Change	Frequency of Occurrence	Range of Distribution	Spring Branch, 1968	Lick Creek, 1968	Laurel Creek, 1971
<i>Strophitus undulatus stuefferianus</i>																					
<i>Alasmidonta marginata</i>																					
<i>Alasmidonta viridis</i>																					
<i>Pegias fabula</i>																					
<i>Lasimigona costata</i>																					
<i>Fusconala edgariana</i>																					
<i>Fusconala barnesiana</i>																					
<i>Lexingtonia dolabelloides</i>																					
<i>Pleurobema ouiforme</i>																					
<i>Pychobranchus fasciolaris</i>																					
<i>Pychobranchus subtentum</i>																					
<i>Actinonassa pectorosa</i>																					
<i>Toxolasma l. lividus</i>																					
<i>Medionidus contractus</i>																					
<i>Villosa iris nebulosa</i>																					
<i>Villosa vanuxemi</i>																					
<i>Lampsilis ventricosa</i>																					
<i>Lampsilis fasciola</i>																					
Total Naiad Species Recorded	0	2	3	5	5	5	6	7	7	10	12	13	17	16					0	2	6
<i>Pleurocera uncialis</i>																					
<i>Goniobasis simplex</i>																					
<i>Spirodon patula</i>																					
<i>Anculosa subgibbosa</i>																					
<i>Io fluviatilis</i>																					
Total Pleurocerid Species Recorded	0	2	1	2	2	3	3	3	3	3	3	3	3	1					0	0	2

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IN THE PATH OF A WARM, SALINE EFFLUENT

*R. D. Turner**

Problems arising from warm effluents, particularly in rivers, are not new and it is not the purpose of this paper to review the subject. Rather it is to show what can happen and will happen with increasing frequency as additional fossil fuel or nuclear powered plants are constructed along our coastline.

In December 1969 the Jersey Central Power and Light Company began the operation of the Oyster Creek Nuclear Generating Station at Forked River, New Jersey. The town of Forked River was chosen for the site of the plant because: 1) the proximity of the South Branch of Forked River and Oyster Creek allowed the use of the former stream as the 'intake canal' or source of cooling water and the latter as the 'discharge canal'; 2) the area is rural but within 50 miles of New York City and Philadelphia and 3) the prevailing offshore winds would carry most air pollutants out to sea.

Unfortunately I was not acquainted with the area before the plant went into operation so cannot make 'before and after' comparisons on a personal basis. However, papers by Nelson and others at the New Jersey Agricultural College Experiment Station, plus a first hand knowledge of present conditions in neighboring creeks give a good idea of conditions in these creeks before 1969. Like other small streams which margin the western shore of Barnegat Bay they used to be freshwater to within a short distance of their entrance into the bay. The depth and extent of the saltwater wedge on the bottom varied from time to time in accordance with the rainfall and subsequent run-off from the land (Nelson, 1922). Based on personal observations, discussions with local residents, and tests made in neighboring creeks during the past two and one half years, it is apparent that formerly Oyster Creek often had ice in the winter and in summer was a comfortable temperature for swimming. We know that "Oyster Creek, which was freshwater to about 2,500 feet downstream of US

Route 9, is now salt-water from its entrance into the discharge canal above the highway to its mouth".¹ Salinities in the creek now range from 12‰ to 25‰ and the temperature of the water, except when the plant is shut down, never drops below 10° C in the winter and may reach 36° C in summer. The rate of flow and the volume of Oyster Creek (the discharge canal) has increased tremendously as a result of the 460,000 to 1,240,000 gallons of water per minute circulated by the plant for cooling purposes. The amount varies in relation to the temperature of the water in Barnegat Bay.

Forked River and its South Branch may now be considered an arm of Barnegat Bay because the current is up-stream so that the temperature and salinity of the water is the same as the adjacent waters of the Bay. As a result of these changes freshwater species have been eliminated from both creeks below the plant and various marine species are gradually invading them. Though data are being accumulated on several species, in this short paper I will concentrate on the invasion of marine boring bivalves (Teredinidae), the group with which I have been most concerned.

Marinas and small docking facilities have been a part of the Oyster Creek environment since 1944 but it was not until the summer of 1971 that the owners of these facilities became aware of shipworms (Teredinidae) in the creek. At the request of the marina owners I visited the area on August 25, 1971 and was shown a portion of the keel of a yacht (Fig. 1) which had been attacked by borers. Since the yacht could have picked up the borers in Barnegat Bay, where they are known to exist, native and trash wood in the creek was examined for borers and several specimens were found.

¹ Draft Environmental Statement by the Directorate of Licensing, U.S. Atomic Energy Commission related to the Oyster Creek Nuclear Generating Station, Jersey Central Power and Light Company. Docket No. 50-219, Chapter 5, p. 17, paragraph 5.5.21. July 1973.

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It can be speculated that one of the yachts brought the borers into the creek, and perhaps one did. This, however, has nothing to do with the problem because wooden ships and floating wood have been carrying shipworms around the world since man first started plying the seas. In fact, during the days of exploration and until metal ships became common, ports were, whenever possible, located well up rivers where the low salinity would kill off both boring and fouling organisms. The point here is that conditions in Oyster Creek have changed. This stream, once a safe place for untreated piling and wooden ships, is now heavily infested.

Before discussing further the present situation in Oyster Creek it is important to consider the biology of the species of borers found there. Two species of Terebinthidae, *Bankia gouldi* (Bartsch) and *Teredo navalis* Linnaeus, occur in Oyster Creek in an area extending from its mouth upstream at least as far as Sands Point Marina. The following life history data were obtained from laboratory experiments and field observations (Culliney, 1969; Turner, 1966, 1971).

Adult *Bankia gouldi* (Bartsch) can tolerate salinities ranging from 10‰ to 35‰ and temperatures from 5°C to 33°C. They are oviparous and spawn between 17.5°C and 30°C. At 25°C and a salinity of 30‰ development of the larvae from fertilization of the egg to the pediveliger stage takes about 25 days. The larvae grow normally at salinities of 10‰ to 32‰, but do so more slowly below 19‰. Development from settlement to sexual maturity at 22°C to 25°C and a salinity of 30‰ requires about 33 days. Thus generation time ranges from 2 to 3 months.

Adult *Teredo navalis* Linnaeus can tolerate salinities ranging from 5‰ to 32‰ and temperatures from 2°C to 35°C (Blum, 1923). They are short-term larviparous species and brood the young to the straight-hinge veliger stage. The young are released at temperatures ranging from 13°C to 30°C and their planktonic life at 25°C and a salinity of 30‰ lasts about 15 days. The larvae can tolerate salinities ranging from 10‰ to 30‰ but grow slower at salinities below 15‰. Sexual maturity is reached about 33 days after settlement at temperatures of 22°C to 25°C (Culliney, 1969) and in 24 days at 80°F to 86°F [=27 - 30°C] (Potts, 1920). Thus this species has about the same generation time as *B. gouldi*.

Teredo navalis differs from *B. gouldi* in being able to tolerate slightly lower temperatures and salinities and in having a planktonic period of about 15 days while that of *gouldi* is about 25 days.

In the summer of 1921 there was a sudden, heavy attack of *Teredo navalis* in the inner area of Barnegat Bay. Nelson (1922) published a paper, "The European Pileworm, a dangerous marine borer in Barnegat Bay", based on this occurrence. He described its attack on the oyster platforms in tidal creeks entering the bay and compared it to *Bankia*

fimbriata Jeffreys [= *B. gouldi* (Bartsch)] as the species in the bay was then called. Nelson felt that the sudden influx of *navalis* was a result of an increase in salinity to 10‰ caused by the drought, 1921 being one of the five driest years on record. This no doubt was part of the answer but the reduction of dissolved plant material in the water resulting from the decreased run-off was probably equally important. Culliney (1973) has shown that the larvae of *T. navalis* are far more susceptible to humic materials in the water than those of *B. gouldi*. An estuarine area draining extensive marshes such as are found along Barnegat Bay receives large amounts of humic materials during heavy rains so that the water becomes red or tea-colored. At such times there is a marked drop in the numbers, if not local extinction, of *T. navalis* larvae in the plankton. During the 10 year drought which plagued the area the reduction in humic materials, combined with the increased salinity near the mouths of the creeks, made conditions ideal for the influx of *T. navalis* and the increase of breeding populations.

It is evident that the relative abundance of these two species, the ranges of which overlap, may vary in a given locality according to conditions. Though *T. navalis* may be found in the inner areas of Barnegat Bay it is not as common there as *B. gouldi* and its populations fluctuate from year to year. In the outer part of the bay and at localities not so greatly influenced by marsh run-off such as Sandy Hook, Barnegat Light at the Coast Guard Station, the light ship off Sandy Hook, and Cape May, *Teredo navalis* is the dominant species (Wallour, 1960). This distribution pattern seems to reflect the sensitivity of *T. navalis* to humic materials in the water.

Nelson (1924) stated that pumped water samples taken close to piling at Barnegat Pier contained 88 mature terebinthid larvae per 100 qt sample, while the greatest number taken in a 100 qt sample in the open bay was 10. On the basis of this he agreed with Harrington (1921) that wood extracts attract larval terebinthids. He suggested that, as the tidal currents carried the borer larvae past the piling some substance exuding from the wood caused them to congregate there. These field data support laboratory experiments showing that mature larvae have the ability to detect wood and to settle even in the face of rather strong currents such as those which now exist in Oyster Creek.

In order to prove the existence of breeding populations of terebinthids in Oyster Creek and the fact that the larvae could mature and settle despite the strong current, a series of collecting panels were exposed. Two sets, one inshore and one off-shore (at the outer ends of the wharves), were put out at each of the three marinas with which we were working, and an additional set was put at the mouth of Oyster Creek. A set of control panels were exposed in Stout's Creek, a stream which, according to those acquainted with the area, is similar to what Oyster

Creek was like in the 1960's. An additional control set was exposed at Holly Park, an area known to harbour shipworms.

Panels measuring 8" x 4" x 3/4", of straight grained soft pine were attached to horizontal racks and set about 6 inches above the water-sediment interface. The first sets of 12 panels, plus a control were exposed on September 7, 1971, and one panel plus a monthly control were removed each month until September 1972. A second series was submerged at the same sites on August 18, 1972 and these are being removed in the same fashion. These tests, show that the attack in Oyster Creek was light during the first year but increased noticeably after the July-August spawning (Fig. 2). Reproductive success and the growth of breeding populations in the creek is evidenced by the heavy attack on the panels removed during the period from October 1972 to March 1973 (Fig. 3). Both *B. gouldi* and *T. navalis* occur in the panels and both appear to breed more than once a year. The spawning periods of the two species do not seem to coincide though further testing is needed to prove this. The greatly increased volume of water in the creek apparently reduces the concentration of humic material following heavy rains to a level below that which affects *navalis*.

At Stout's Creek, the control locality, only a single specimen (1 cm long) of *B. gouldi* was found in the panels. The occurrence of a borer at this site probably results from the dredging now going on in the creek, which allows the salt water wedge to creep upstream. Cold winter temperatures (2.5°C) and low salinities will, however, keep populations in such a situation at low levels.

As would be expected, none of the first series of Holly Park panels was attacked until after the June-July spawning as evidenced by the 54 young *B. gouldi* in the control and 45 in the panel removed August 18, 1972. Only one specimen has been found in the second series of panels (submerged August 18, 1972) so it would appear that most of the *B. gouldi* larvae had matured and settled prior to that date. This is in contrast to stations in Oyster Creek where settlement of *B. gouldi* continued into November and *T. navalis* settled in February. No *T. navalis* were taken in the Holly Park panels though the species had been found in the area previously. This probably reflects variations in the amount of humic materials in the water at this site.

On the basis of these data it appears that: 1) As a result of the effluent from the Jersey Central Power and Light Company Plant, temperature and salinity conditions in Oyster Creek are now suitable for continued growth of both *B. gouldi* and *T. navalis*. 2) The warm water has increased the growth rate, extended the breeding season and eliminated winter kill-offs of these species. Consequently the breeding populations are kept at high levels and population increase enhanced. 3) To date the temperature in Oyster Creek has not risen high enough in summer to

exceed the tolerance of the borers and so reduce the populations. This, however, should never be allowed to happen as it would result in the death of nearly everything else in the creek. 4) The attack of marine borers is so severe that, if present conditions continue, it will be necessary to replace piling and other structures periodically, even if they are treated, and check all wooden vessels at frequent intervals. 5) If the isopod crustacean borer, (*Limnoria*) known to occur in Barnegat Bay, is introduced into Oyster Creek it will also become a problem as will any tropical borer accidentally carried in by yachts. 6) Though the fouling organisms have not been studied in detail it is evident that *Balanus eburneus* Gould (Pilsbry, 1916), the most noisome of the foulers, are growing faster and have a longer breeding season than is typical for other areas in Barnegat Bay.

Several additional problems attributable, I believe, to the operation of the plant also plague Oyster Creek and should be mentioned briefly.

The silt load of the creek below the plant has increased greatly as it now receives in addition to its normal load the run off from both the South Branch and the Middle Branch of Forked River which were captured in the "intake canal". Added to this is the silt resulting from the severe erosion of the unprotected banks of the Creek just below the plant. Where the Creek widens in the vicinity of the Marinas the current lessens and the silt burden is dropped in the dock area. On several occasions I have seen yachts get stuck on mud banks as they entered the Marina.

In cool and humid weather, vapors rising from the heated water of the Creek produce fog. The consequent continuous damp atmosphere results in the development of mold, mildew and dry rot on the wood panelling, seats and furnishings of the yachts as well as the corrosion of instruments and metal fixtures.

An unsightly "sludge" apparently from the plant, comes down the creek at irregular intervals and fish kills result from thermal shock when the plant shuts down in winter. Though these do not affect the Marinas directly they do affect the water quality and are unpleasant.

What has happened in Oyster Creek may occur in any area where such changes in the environment occur. Certainly whenever thermal effluents enter the marine environment in temperate and boreal waters marine boring and fouling problems can be expected to develop in the vicinity of waterfront structures.

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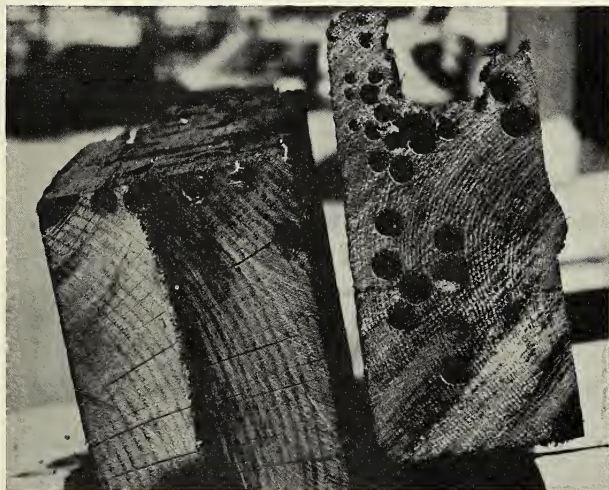


Fig. 1 Borer damage in keel of yacht, Oyster Creek Marina, Oyster Creek, Waretown, New Jersey, August 1971.

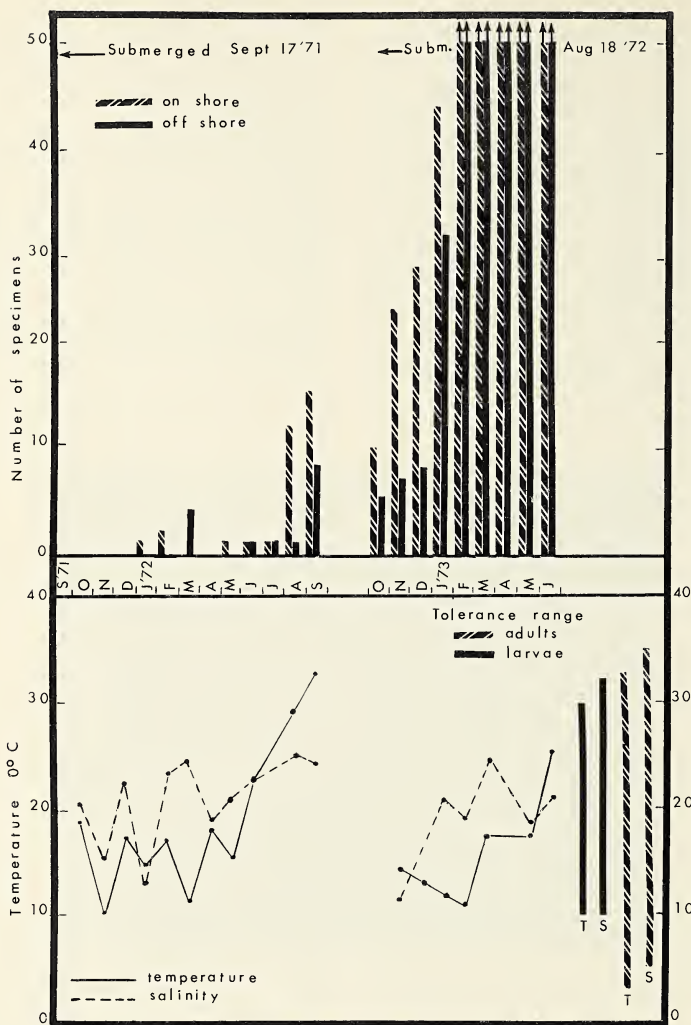


Fig. 2 Graph showing borer attack at Sands Point Marina, Oyster Creek, Waretown, New Jersey, Sept. 1971 to June 1973, temperature and salinity records taken at time the panels were removed and ranges of tolerance of the adults and larvae.

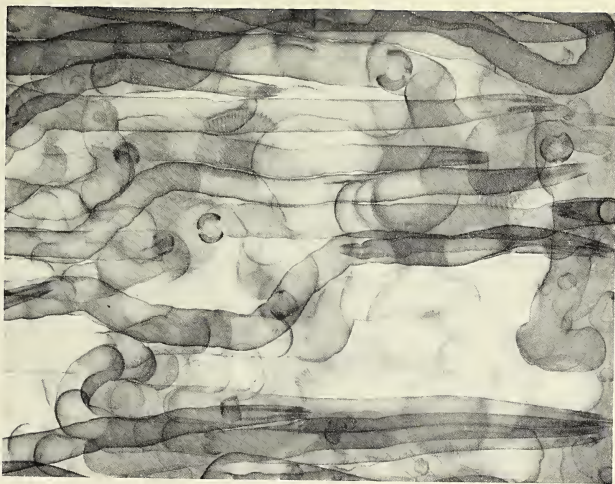


Fig. 3 X-ray of a portion of panel exposed at Briarwood Yacht Basin, Oyster Creek, Waretown, New Jersey, from Aug. 1972 to June 1973 showing extent of attack (nat. size).

ABSTRACTS OF PAPERS
READ AT AMU 39th ANNUAL MEETING

FURTHER MICROANATOMICAL STUDIES OF *DENTALIUM*

Ken Bazata*

The shells of Dentalium pilsbryi and D. texasianum are confusingly similar. Observations of living specimens reveal that strikingly different foot characteristics permit separation of these two species without any question. D. pilsbryi has a spade-shaped foot with two erectile lateral flaps which aid in burrowing. D. texasianum has an elongate, cylindrical foot without flaps.

Serial sections of the siphonal ends show a more complex valve system in D. pilsbryi. D. pilsbryi has a pair of valve flaps dorsally and a single ventral valve flap. D. texasianum has a pair of single, overlapping valve flaps. In one serially sectioned specimen, assignable to D. texasianum on the basis of the foot characteristics, there was no valve system at all, but simply a solid transverse septum.

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A SURVEY OF BRITISH COLUMBIAN FRESHWATER MOLLUSKS:
PRELIMINARY RESULTS

Arthur H. Clarke*

*In August, 1972 freshwater mollusks were collected, ecological observations were recorded, and water analyses were performed by A. H. Clarke and B. T. Kidd at approximately 100 localities throughout British Columbia. Some taxonomic problems are still unresolved so a complete report cannot be presented at this time. Preliminary results indicate that: (1) *Anodonta nuttalliana* Lea (= *A. wahlamatensis* Lea) occurs together with *A. kennerlyi* Lea in the Fraser and Columbia river systems and the two species are distinct; (2) scanning electron microscope photographs show that the radula of *Lymnaea atkaensis* Dall is closely similar to that of *L. stagnalis* L. but dissimilar to that of *L. catascopium* Say; (3) in Lake Wabamun, Alberta, *Helisoma trivolvis subcrenatum* Carpenter and H. binneyi (Tryon) intergrade completely; (4) 40 to 50 freshwater species are present in British Columbia, and (5) four zoogeographic groups are present, viz.: Central West Coast endemics (ca. 35%); Beringian relicts (ca. 5%); widespread boreal and subarctic species (ca. 55%), and introduced species (ca. 5%). Further field work is planned for 1973.*

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OXYNOE ANTILLARUM (MORCH) AND LOBIGER SOUVERBIEI
(P. FISCHER) ON FLORIDA'S LOWER GULF COAST
(OPISTHOBRANCHIA: OXYNOIDAE)

Charles M. Courtney*

In an effort to develop baseline data on fish and invertebrate abundance in the waters surrounding Marco Island, Florida, a regular monthly trawl monitoring study was begun in July of 1971. Several living specimens of *Oxynoe antillarum* (Morch) and *Lobiger souverbiei* (P. Fischer) appeared for the first time in 1973 and were most abundant over a scoured sand bottom which was sparsely populated by the algae *Caulerpa* spp. The sudden appearance of the two oxynoids marks the first appearance of *O. antillarum* on Florida's lower west coast and reaffirms the presence of *L. souverbiei*.

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ANNUAL CHANGES IN POPULATIONS OF TWO INTERTIDAL GASTROPODS
(*NASSARIUS OBSOLETUS* AND *LITTORINA SAXATILIS*) AT CAPE ANN,
MASSACHUSETTS, 1956-1972

Ralph W. Dexter*

Annual changes in abundance of these two species in the Cape Ann area between 1933-37 have previously been described by the writer (*Nautilus* 58:18-24, 1944). At Station J, a mud flat on Little River, a side channel of the Annisquam Tidal Inlet, single annual counts of *N. obsoletus* from various tidal levels were made between 1956-64, along with other marine invertebrates. A special report was published for 1960 (*Nautilus* 75: 85-86, 1961). Between 1965-72, 10 random samples of this snail were counted annually along the level of greatest concentration. The range and average number per quarter square meter were as follows: 1965 (62-122, 91); 1966 (19-92, 38); July 1967 (19-100, 48); Sept. 1967 (24-189, 97); 1968 (105-375, 203); 1969 (32-419, 162); 1970 (19-86, 42); 1971 (0-19, 6); 1972 (0).

After preliminary observations during 1963-65, the range and average number per quarter square meter for *L. saxatilis* at High Bank section of Whale Cove on the open ocean off Rockport, between 1966-72, were as follows, from 10 random samples taken at the level of greatest density: 1966 (0-14, 5); 1967 (11-51, 19); 1968 (24-103, 53); 1969 (0-22, 6); 1970 (24-46, 33); 1971 (0-16, 8); 1972 (5-49, 30).

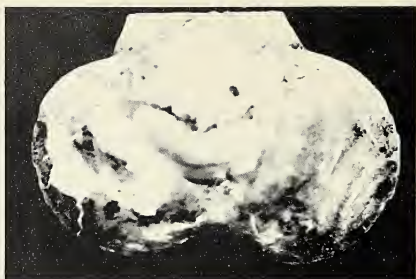
These snail populations, sampled in the summer season, fluctuate widely and fortuitously from year to year at the same locality. During three summers, 1960, 1961, and 1972, the entire population of *N. obsoletus* completely left the sampling station, apparently as a result of schooling behavior as described by Jenner (*Biol. Bull.* 113:328-329, 1957).

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A TRILOBED SHELL OF
PLACOPECTEN MAGELLANICUS
 (GMELIN)

Ralph W. Dexter*

Merrill has reported on abnormal shells of the Atlantic deepsea scallop *Placopecten magellanicus* (Ann. Rept. Amer. Malacol. Union for 1964, p. 2; *ibid.* for 1966, pp. 35-36; U.S.F. and W.S. Fishery Bull. 66: 273-279, 1967). An unusual specimen consisting of three lobes (anterior, posterior, and lateral) was taken by a fishing dragger on Brown's Bank off the coast of New England in June, 1966, and given to the writer by John B. Auditore (Marine Biological Supply, Gloucester, Mass.). It is 12.2 cm in length, 8.5 cm in height, and 4.4 cm in thickness and its age is five years. Possibly a growth of encrustation caused the abnormal growth, but more likely it either



Trilobed *Placopecten magellanicus* from Brown's Bank.

*Dept. of Biological Sciences, Kent State University, Kent, OH, 44242

suffered a physical blow at the middle, ventral margin, or it hit an obstruction while growing which caused the mantle to form the three lobes.

CRITERIA EMPLOYED IN THE RECOGNITION AND DESCRIPTION
 OF *OXYLOMA DEPRIMIDA* FRANZEN

Dorothea Franzen*

Distinctive characteristics of *Oxyloma deprimida* Franzen are: 1. The nuclear whorl is depressed. The tip of the nuclear whorl appears to be somewhat "tucked in" under the penultimate whorl. 2. The epiphallus enters the penis subterminally producing a terminal extension of the penis, the penial appendix. In *O. deprimida* the base of the penial appendix is broad which makes it appear to be a terminal extension of the penis rather than an appendix distinctly separated from the body of the penis by a constriction as in, for example, *O. haydeni* (W. G. Binney). The epiphallus enlarges as it approaches the penis and merges imperceptibly with it. 3. The albumen gland is smaller than is the prostate gland. The acini of the albumen gland are smaller than those of the prostate gland. The relatively large, twinned, unequal seminal vesicles are coarsely peppered with black pigmentation, whereas the inflated fertilization sac is lightly pigmented. The large, coiled hermaphroditic duct is darkly pigmented. 4. This species does not live on the ground but 3 to 5 feet above the ground and/or water level, on cattails and willows. 5. *Oxyloma deprimida* matures in September or October which is several months later than the maturation time of other species of *Oxyloma* as known in the Mississippi Valley.

*Illinois Wesleyan Univ., Bloomington, IL. 61702.

ASPECTS OF THE ANATOMY OF *CIONELLA LUBRICA*

Carl W. Gugler*

The appearance of the penial complex varies greatly, according to its degree of activation. In the inactive state the epiphallus region is slightly larger than vas deferens; when active it is markedly distended and glandular. In the inactive state the penial appendix is slender and uniform in diameter, distal to a basal bulbous element; when active, the distal end is greatly swollen and the basal bulb exhibits an internal valve-like structure.

In the inactive state the digitiform prostate glands are minute; when active they are greatly swollen and packed with eosinophilic granules. Granules of similar appearance, encased by a hyaline substance are found in the swollen distal end of the active appendix. Similar granules also are found in the active spermatheca. In no case have spermatozoa been observed in either the active appendix or the active spermatheca.

At the junction of the albumen gland, spermoviduct, and little hermaphroditic duct, a slender tube, the talon, extends over the surface of the albumen gland. In some of the specimens examined the talon contained unoriented spermatozoa.

*Dept. of Zoology, University of Nebraska-Lincoln, Lincoln, NE. 68508.

CHARLES WRIGHT (1811-1885) IN CUBA

Morris K. Jacobson*

Charles Wright, the well-known American botanist and collector, — princeps longae collectorum (by far the first of collectors) as he was called by Grisebach — collected land shells extensively in Cuba during the years 1856 and 1867. Approximately 30 names of new species of land shells were credited to him by Pfeiffer and others. It is shown that in all likelihood Wright suggested the names alone, that the descriptions were not written by him, and that the species should be credited to Pfeiffer, Sowerby, Orbigny, Presas and others. A complete list of these nomina and their latest forms, together with a brief account of the life of Wright has appeared in Sterkiana, No. 53: 1-6, 1974.

*455 Beach 139th Street, Rockaway Beach, NY 11694

MARINE MOLLUSCAN DISTRIBUTION/DENSITY SURVEY:
A PROPOSAL TO THE AMU

Lawrence E. Jerome*

The author introduced the concept of an expert opinion survey to determine molluscan population changes which may have occurred within the memory span of malacologists and conchologists. He pointed out that this information is irretrievable by any other means and suggested that the AMU sponsor and/or participate in such a survey.

*He discussed the relevant statistics for the survey and demonstrated that an order of magnitude may be a realistic tolerance. He proposed a scale for rating relative abundances similar to that used by bird watchers and based on this factor-of-ten tolerance.***

Surveys are usually conducted with a "schedule" or questionnaire; the author presented a sample check list which might serve as a questionnaire for the proposed survey. He then discussed the handling and mapping of the data, which must first be normalized and their standard deviations determined.

Finally, the author discussed the use of topographical maps for obtaining environmental data which is suitable for making correlation studies between environmental and molluscan population changes.

* 1467 Navarro Drive, Santa Clara, CA 95051

**An *ad hoc* AMU committee is studying this proposal and will present its findings to the AMU Council in 1974. Ed.

GATUN LAKE AS A FRESHWATER BARRIER IN THE PANAMA CANAL

Meredith L. Jones*

A general orientation of the geographical and physical characteristics of the Panama Canal was presented. Data obtained with a Beckman Model RS5-3 Portable Salinometer indicates that a freshwater continuum (or essentially so) extends from Miraflores Lake through the Pedro Miguel Locks and Gatun Lake, to, and including, the highest chamber of the Gatun Locks. This forms an effective barrier against the migration of stenohaline organisms between the Atlantic and Pacific Oceans. Comments were made concerning the vertical homogeneity of the water masses within the lock chambers.

*National Museum of Natural History, Smithsonian Institution, Washington DC 20560.

REPRODUCTION AND DEVELOPMENT IN *SPIRATELLA INFLATA* (D'ORBIGNY), A THECOSOMATOUS PTEROPOD*

C. M. Lalli** and F. E. Wells, Jr.**

Reproduction and development of the protandric hermaphrodite, *Spiratella inflata*, was studied in Barbados, West Indies. Specimens larger than 1.1 mm in shell diameter are mature females, constituting 1.9% of the total population. The characteristic inflated body whorl and expanded mantle cavity of *S. inflata* form a spacious chamber, in which females brood young through the early veliger stage. Embryos begin development at the posterior portion of the mantle cavity near the common genital pore and move forward adhering to the mantle lining as they develop. Lack of a capsule or mucus around the eggs and embryos is correlated with the absence of albumen and mucous glands in females. Veligers released by the parent have a sinistral shell of one whorl measuring 0.067 mm in diameter. A bilobed velum, eyespots and foot with a transparent operculum are present upon release. Wing rudiments later develop in free-swimming veligers and metamorphosis to the adult state is complete at 0.4 mm shell diameter.

* Research supported by Grant No. A5248 from the National Research Council of Canada to CML.

**Marine Sciences Centre, McGill University, Montreal, Quebec, Canada.

FROG MOTIFS ON ARCHAEOLOGICAL MOLLUSKS OF HOHOKAM AND MOGOLLON INDIAN CULTURES

Glenn A. Long*

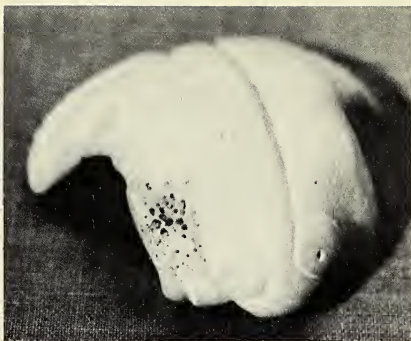
This is a preliminary report of research on carved shell ornaments from archaeological remains of pre-Historic Indian cultures in the Southwest. In the current phase of study, a checklist of frog images is being compiled and motif groups are being catalogued. Forty-three pendants and eight bracelets carved with frog motifs, or overlaid with turquoise mosaic, comprise the initial checklist.

Of the carved pendants without overlay, several motif groups can be identified. The bracelets with frog images carved on the umbonal region of the shells are less varied in form than are the pendants. The pendants and the bracelets were made from whole valves of various *Glycymeris* species, such as *G. gigantea* (Reeve) and *G. maculatus* (Broderip). Other shells were also used but less frequently.

Frog motifs are not restricted to worked shell. Stone and clay vessels are known from the Southwest which incorporate frog images in relief modelling and carving.

Conclusions which can be drawn, so far, are few.

*The Baltimore Museum of Art, Baltimore, MD. 21218.



Shell (*Glycymeris gigantea* (Reeve)?, carved in the form of a frog, Hohokam, Central Arizona (P:14:14). From the collections of the Arizona State Museum (A23646) (Photo by G.A. Long).

Among them we have found that: (1) incidence of carved frog pendants is rather frequent in archaeological contexts throughout the Hohokam and Mogollon culture areas and (2) that when not found in association with architectural fill and floor debris, the pendants have been excavated most frequently in connection with burials.

FOSSIL AND LIVING FRESHWATER MUSSELS (UNIONACEA) FROM THE PECOS RIVER, NEW MEXICO AND TEXAS

Artie L. Metcalf*

The Pecos River arises in north-central New Mexico, traverses eastern New Mexico and western Texas and empties into the Rio Grande above Del Rio, Texas. At the present time, its discharge is rigidly controlled by a series of reservoirs and the river terminates in Amistad Reservoir. The middle reaches of the river suffer from salinization and from some pollution from oil fields.

The lowest segment of the river is deeply entrenched in Cretaceous limestone, suggesting a relatively great age for that part of the valley. The mid-upper part in eastern New Mexico seems, however, to be relatively young, having removed Pliocene sediments that presumably formerly occupied the valley.

At present, unionaceans are found almost exclusively in the lowest, canyonlands part of the river. A few collections made in the past indicate that the richest fauna was at the mouth near the Rio Grande in that area now covered by Amistad Reservoir. At least two species still persist in the lower river: *Popenaias popeii* (Lea) and *Cyrtonaias grandensis* (Conrad) and the former may still persist in southern New Mexico.

Holocene bank deposits along the Pecos in its middle section have yielded radiocarbon dates in the range of 3600 to 1130 years B. P. These deposits also contain only the two species listed above. One late Pleistocene locality near Toyah, Texas, contains *Anodonta grandis* Say and a lampsiline tentatively assigned to the genus *Disconaias*.

At what is judged to be a still older (undated) Pleistocene locality below Lake McMillan (a reservoir) in New Mexico, the same *Disconaias* (?) occurs along with another, unidentified *lampsiline*, a *Quadrula*, and *Megalonaia nervosa* (Raf.).

Affinities of the Lake McMillan fauna seem to be with the lower Rio Grande system and possibly some systems to the south of it. Construction of a new reservoir that will inundate the Lake McMillan fossil locality has been authorized.

*Department of Biological Sciences, University of Texas at El Paso TX 79968.

NORTH CAROLINA SCALLOP FISHERY, 1972-1973

Hugh J. Porter*

This talk was illustrated by a silent 16 mm motion picture documenting the fishery. Location, description, and investigative efforts of the 1972-1973 fishery were covered. Scenes showing scallops being caught, types of gear used, fauna associated with scallops, unloading of scallop catch and pictures of scallop processing by automatic scallop shucking machinery were included. Research and development of film was supported by Grant #456 of the North Carolina Board of Science and Technology.

*Institute of Marine Sciences, University of North Carolina, Morehead City, NC 28557.

THE EFFECTS OF TEMPERATURE ON GROWTH AND REPRODUCTION IN AQUATIC SNAILS

Henry van der Schalie* and Elmer G. Berry*

Nuclear reactors, either built or projected, are destined to bring large amounts of heat into lakes, streams and regions where natural waters will be used to cool the machinery in nuclear power stations. This may have profound effects on the resident populations of freshwater mollusks. The research, which is partially summarized here, sought to determine what these effects might be. The study extended over a three-year period and used seven species of freshwater snails for stressing in aquaria with temperatures ranging between 6°C and 36°C at 6°C intervals. Following the initial tests, the same species were again tested in aquaria at 2°C intervals in a temperature range compatible for each. Species tested included: *Lymnaea stagnalis* and *L. emarginata* (= *castacopium*); *Helisoma trivolvis*, *H. anceps* and *H. campanulatum*; *Physa gyrina*; and *Amnicola limosa*.

The results can be summarized by noting that the *lymnaeids*, which have a northern distribution, grow best under "cool" conditions (about 18° to 20°C) with egg-laying somewhat better under slightly warmer conditions (22°C); the planorbids cultured better under warmer conditions (about 25°C) with egg production best at about 28°C but restricted at 30°C — conditions that resemble for some species the tropical and sub-tropical environments; the *Physa* tested had the widest range of tolerance in that they grew and reproduced in temperatures ranging between 14°C and 30°C — an indication that this group occupies perhaps the widest range of conditions in nature of any of the snails tested.

The study showed that none of the snails studied could grow and reproduce below 12°C or above 30°C; while all seemed to reproduce better at temperatures higher than their optimum for growth, the adverse effects of heat on the gonads lowered egg production at the upper temperature ranges. Consequently, as shown by gonad tissue studies, temperature approaching 30°C usually results in some degree of sterility. This effect has also been observed on the gonads of fish.

The data, although unfortunately limited largely to the pulmonate ("pond") snails, serve to indicate the dangers to mollusks in regions where the ambient temperatures of an environment will be changed appreciably by effluents from reactors. The tolerances measured also give a better appreciation of climates during interglacial periods which heretofore were designated "hot" or "cool" almost solely on what was known about the geographical distribution of the snails.

This report, with tables and graphs, was recently published in: Ecological Research Series, Environmental Protection Agency, EPA-R3-73-021, February, 1973 and in Sterkiana, No. 50, June, 1973.

*University Museums, University of Michigan, Ann Arbor, MI 48104.

THE MOLLUSKS OF THE DUCK RIVER DRAINAGE IN CENTRAL TENNESSEE

*Henry van der Schalie**

Based on three consecutive years of collecting, A. E. Ortmann (1924) published his observations on the mussels in a paper with the title: The Naiad-Fauna of Duck River in Tennessee (American Midl. Nat. 9:18-62). He reported 63 species and forms and showed that the Duck River contained two distinct faunal elements. The upper river stations (Wilhoite and Columbia) had a Cumberlandian fauna; the lower half below Centerville had a Mississippian (Ohioan or Interior Basin) fauna. In 1931 another survey was made of mollusks of that river system by Calvin Goodrich and Henry van der Schalie, the former concentrating on the pleurocerid snails, the latter on the mussels. The collections reported serve as a supplement to Ortmann's original collections; in the Buffalo River only one headwater station (at Riverside) was established by Ortmann; the present report adds four stations and shows that the Buffalo had as many mussel species as the Duck. All of these records are now significant since in both drainages the mussels have all but disappeared.

When the information contributed by both surveys is combined, the following conclusions are warranted:

- 1) Of the 63 species and forms of mussels reported by Ortmann in his survey, the collections ten years later yielded 48, indicating that this river had a surprisingly rich mussel fauna.*
- 2) The Cumberlandian fauna is restricted in the Duck to stations above Centerville; the lower half of the river contained only Mississippian mussels.*
- 3) The additional four stations established in the Buffalo River indicate that it has a Cumberlandian assemblage. This condition prevails even though the Buffalo enters the lower Duck which is Mississippian and parallels the lower Tennessee which also is entirely Mississippian.*
- 4) Excluding the Buffalo itself, neither drainage now has an appreciable mussel fauna in the tributaries; pleurocerids are still abundant in the smaller streams.*
- 5) For all practical purposes the mussels of both the Duck and the Buffalo have disappeared with only a few dwindling pockets left near Columbia and Centerville in the Duck.*
- 6) The Oriental clam (Corbicula) has made serious inroads into both drainages and tends to crowd out the native mussels; there is evidence they now substitute as food for mink and muskrats.*
- 7) While the mussels are disappearing, the pleurocerid snails remain unusually abundant; Goodrich's studies indicate that there are nine species and three forms; most of them show clinal tendencies.*

Unfortunately, studies involving biomass have never been made, although it is established that the many shoals in this drainage system were virtually paved with mussels and pleurocerid snails. While the mussels have disappeared at an alarming rate, the snails are still legion there.

*University Museums, University of Michigan, Ann Arbor, MI 48104.

AMU COMMITTEE AND BUSINESS REPORTS

REPORT OF AMU ANNUAL BUSINESS MEETING, JUNE 27, 1973

President Dee S. Dundee, presiding, called for a motion to waive reading of the minutes of the previous annual business meeting because they had been printed in the Bulletin for 1972. Motion made, seconded, carried.

The Recording Secretary read reports of the Secretaries and the Treasurer for 1972; they are printed in this Bulletin.

Reports of the various committees to the Executive Council were summarized by the Recording Secretary. The Publications Editor reminded members that, starting with 1973, manuscripts for the Bulletin will be sent to appropriate members of a review board (present members of the Executive Council) prior to acceptance for publication. We have exhausted our supply of HOW TO COLLECT SHELLS and the Fourth Edition has been delayed by lack of a Special Editor for revision.

The Conservation Committee reported that kits with conservation materials had been mailed to member clubs on March 1 and June 1, 1973. The Council authorized Mrs. Merrill, Chairman, to investigate the possibility of our putting out a booklet for fresh water and land habitats similar to the American Littoral Society's "202 Questions for the Endangered Tidal Zone". She will investigate the cost and seek potential sponsors. A proposed Code of Ethics, prepared by Carol Stein and approved by the Council, was presented to the membership and approved. (This was printed in the Fall Newsletter).

The Awards Committee recommended that the AMU establish two annual \$50 prizes. One is to be for the individual member or club member, non-professional, for an illustrated paper related to conservation. The other will be to a member club for a project related to conservation, and will be judged on the basis of a scrapbook.

The budget approved by the Council for 1974 was unbalanced, with anticipated receipts of \$4,100 and budgeted expenditures of \$4,700. The actual deficit will probably be less than \$600 because no increase in income was forecast over 1972, and some budget items may not be fully utilized, especially the increased allowance for printing and postage. The budget includes \$2,500 for the Bulletin, \$600 for the Newsletters (both printing and postage for each), \$200 for Conservation Committee activities, \$500 for miscellaneous expenses and supplies, \$200 for other printing, \$600 for officers' meeting expenses, and a new provision for \$100 in prizes.

The Membership Committee, headed by Dr. J. B. Burch, sent letters to lapsed members, students, and other prospective members. There has been an encouraging recent increase in the number of new members.

The Executive Council moved that the AMU membership express its approval of the principles and endeavors of the Council of Systematic Malacology. This new association considers inter-institutional problems that are not suitable for AMU consideration. Members now include managers of systematic collections of mollusks (i.e. museum curators), and utilizers of resources are also invited. (See *Malacological Review*, No. 6, pp. 73-74 (1973)).

A resolution concerning the maintenance of the existing fresh water barrier in the Panama Canal, as approved by the Council, was presented to the membership and approved. (This Gatun Lake Resolution was printed in the AMU Newsletter (Fall, 1973)). (See also the Abstract of Dr. Meredith Jones' presentation, printed in this Bulletin, for background material relating to the problem).

The site of the 1974 Annual Meeting will be Springfield, Mass. Our hosts will be the Connecticut Valley Shell Club and the Springfield Museum of Science. The dates were subsequently set as August 4 through 8, 1974.

Most of the publications of member clubs, supplied to the AMU over the years, have now been transferred to the AMU Library at the Delaware Museum. Members are welcome to read the scrapbooks and other material available there.

Mr. Emery P. Chace of Lomita, California, was recommended as an Honorary Life Member. The motion was unanimously approved by the membership. Mr. Chace is probably our oldest member, and he still attends meetings of the Conchological Club of Southern California.

The Nominating Committee presented and the membership elected the following slate of officers for the coming year: President, Harold D. Murray; President-Elect, Donald R. Moore; Vice President, Dorothea Franzen; Recording Secretary, Marian S. Hubbard (3 years); Councillors-at-Large, William Lloyd Pratt, Jr. (1 year), Harold W. Harry and James H. McLean (2 years). The other officers do not require election this year.

The Legal Committee has recommended that the AMU remain incorporated in California this year, but re-incorporate in Delaware in 1974 after provision has

been made for a legal address in that state. Proposed changes in the Constitution and Bylaws of the AMU were read and explained, and approved by the members present. They will be confirmed by a mail ballot to all members, which will be included with the Fall Newsletter.

Mrs. Twila Bratcher, as President and on behalf of The Western Society of Malacologists, invited the AMU to hold a joint meeting with the WSM on the West Coast in 1975. (It was later announced that the meeting will be in San Diego). The Executive Council agreed to discuss this in more detail if enough members expressed an interest in such a meeting. Some 70 of the members present, including about 10 who live on the West Coast, said they would expect to attend a Western joint meeting. Since many more papers would be presented, the members were asked if they preferred the usual 4 or 5 day meeting with double sessions, or a week-long meeting. The members seemed to favor the longer meeting, especially because the purpose of meeting jointly was to share each others' interests. Donald Moore and Joseph Rosewater will meet with representatives of the WSM to work on details of a 1975 Meeting.

During the year members of the Conservation Committee tried to make arrangements to get one or more mollusks on the stamps of the National Wildlife Federation. It was moved to have *Io fluviatilis* put on a stamp but that the exact location of the habitat not be published to avoid further depletion of this fresh-water snail.

Under New Business, Mr. Lawrence Jerome of California asked the AMU to support his proposed study of molluscan distribution and density for the East Coast of the United States. He needs money for maps and other materials, as well as help from AMU members and member clubs. (See his Abstract in this Bulletin for details.)

The incoming President, Dr. Harold D. Murray, was introduced and took over the gavel. He announced the chairmen of the various committees of the Executive Council. Among the announcements, Marc Imlay told the members about some developments relating to conservation, but the members could not vote on them because they were not properly presented. Carol Stein will function in a liaison capacity for conservation, collecting cross-specialty information, and working on a conservation directory, something especially needed in the field of endangered species. The Conservation Committee would like to modify last year's resolution of the membership regarding endangered shells in competitive exhibits. They would like the member clubs to exclude not only the species on the official U.S. Government list, but those included in an International Convention, the so-called World List.

The members passed most enthusiastically a resolution thanking Dr. Abbott and the Delaware Museum.

Respectfully submitted, Marian S. Hubbard, Recording Secretary.

REPORT OF THE CORRESPONDING SECRETARY FOR 1972

Mail came in about the same rate as last year, with possibly a slight increase. It was averaging about a letter a day. About 50 per cent of this mail was from youngsters, grammar to high school. Those in high schools were using shells in their science projects.

Most of the mail was answered through one of five types of form letters or informational lists. A few required more thought and additional comments. A small percentage was from overseas with most of those, strangely enough, from the Philippines, where apparently sales of shells is a thriving business in theory if not in actuality.

There is still high demand for "How to Collect Shells," with checks, money orders and crumpled dollar bills returned with a form letter indicating that we hope another edition will be out soon and we'll let them know when it's available again.

Membership applications go out to any who appear to be that interested in becoming members, especially where no state club or regional organization on malacology is nearby.

Respectfully submitted, Paul R. Jennewein, Corresponding Secretary.

REPORT OF THE RECORDING SECRETARY FOR 1972

As of January 1, 1973, the membership of the AMU was 760, showing a net increase of 41 individuals and 2 clubs over the previous year. The

following is a comparison, by category, with the previous two years:

	<u>1/1/71</u>	<u>1/1/72</u>	<u>1/1/73</u>
Individual	510	451	479
Individuals under Family Membership (2 or more people per membership)	235	190	208
Honorary Life Members	9	8	6
Corresponding Members	37	23	20
Clubs and Regional Organizations	<u>32</u>	<u>45</u>	<u>47</u>
TOTAL	823	717	760

In the fall of 1972, about 70 members were dropped for non-payment of dues. The efforts of the Membership Committee, headed by Jack Burch, started early in 1973 and appear to be bearing fruit. Personal letters sent to lapsed members have so far resulted in 11 people re-joining, mostly paid for 1972 as well as 1973. Letters were also sent to students and scientists not then members of the AMU. In addition, information about AMU membership was sent to all MALACOLOGICAL REVIEW subscribers, and there was a notice in the April issue of THE NAUTILUS about both the Annual Meeting and membership. New members do not always tell us why they joined, but many people joining this year did not have the Application for Membership form sent out by the Corresponding Secretary. As of June 6, 1973, membership was up to 836, including 50 organizations and 25 corresponding members. However, we expect that upwards of 50 of these 836 will be dropped by year-end for non-payment of 1973 dues.

Although I am only Recording Secretary, I try to quickly answer correspondence that requires only a

form or a few words. I pass along more involved inquiries to Paul Jennewein. Including welcome letters to new members, I sent out about 50 pieces of mail a month. I find that even after almost 3 years this office is never "routine". I write an individual letter to each new member because in most cases I am giving or requesting information that could not be covered by a form. As much as possible I read the various club publications and advertising material that arrives. I pass along information to other officers and committee chairmen when I think they would be interested. Since last October I have had frequent correspondence with Myra Taylor, the new Treasurer. We have a number of points to present to the Executive Council for advice and guidance relating to our activities. This is an attempt to codify our current practices and to ensure that the Council is aware of all of our activities. It will take continued effort to make the system work efficiently.

Respectfully submitted, Marian S. Hubbard,
Recording Secretary.

REPORT OF THE TREASURER FOR THE FISCAL YEAR ENDING DECEMBER 31, 1972

CHECK BOOK BALANCE, JANUARY 1, 1972.

1874.65

RECEIPTS:

Memberships:	Regular	2609.75	
	Corresponding	88.25	
	Clubs & Institutions	<u>246.00</u>	2944.00
Sales:	HOW TO COLLECT SHELLS	256.12	
	RARE & ENDANGERED SPECIES	8.05	
	Back Issues-Bulletin	<u>165.75</u>	429.92
Proceeds of Galveston Meeting		315.78	
Page charge to authors		199.50	
Interest on Savings Certificate		166.60	
Miscellaneous credits		<u>11.75</u>	<u>693.63</u>
Total Receipts from activities			4067.55
Transferred from Savings Account			<u>500.00</u>
			<u>4567.55</u>
TOTAL CASH TO BE ACCOUNTED FOR:			<u>6442.20</u>

DISBURSEMENTS:

Printing:	Annual Report	2292.85	
	Other printing	<u>206.45</u>	2499.30
Postage		410.20	
Bank charges		25.44	
Office expenses		153.83	
2 Secretaries' expenses — annual meet.		560.00	
Filing Fee-State of California		10.00	
Miscellaneous expenses		<u>21.50</u>	<u>1180.97</u>
Total Disbursements			3680.27
Check Book Balance, December 31, 1972			<u>2761.93</u>
TOTAL CASH ACCOUNTED FOR:			<u>6442.20</u>

Savings account B14592, Colonial Federal Savings & Loan Association.

Balance, Jan. 1	2595.50	
Interest	<u>82.20</u>	2677.70
Withdrawal to checking account		<u>500.00</u>
Balance 10/31/72		2177.70
Withdrawn and sent to Myra Taylor		2177.70
Savings Account #8289670, Broadway National Bank		
Opened account, November 15, 1972		2177.70
Balance, December 31, 1972		<u>2177.70</u>
TIME CERTIFICATE OF DEPOSIT # 6659, Broadway National Bank		3000.00
RECAPITULATION OF ASSETS, DECEMBER 31, 1972:		
Cash in Checking Acct., Broadway Nat'l. Bank		2761.93
Treasurer's Petty Cash — Myra Taylor		25.00
Secretary's Petty Cash — Marian Hubbard		100.00
Savings Account #8289670, Broadway Nat'l. Bank		2177.70
Time Savings Certificate #6659, Bdy. Natl. Bank		<u>3000.00</u>
TOTAL ASSETS		8064.63
Allocated to Life Membership Fund		<u>1470.88</u>
A. M. U. NET WORTH — DECEMBER 31, 1972		<u>6593.75</u>
CHANGES IN CAPITAL ACCOUNT:		
A.M.U. CAPITAL ACCOUNT, JANUARY 1, 1972		6109.27
A.M.U. CAPITAL ACCOUNT, DECEMBER 31, 1972		<u>6593.75</u>
NET INCREASE IN ASSETS, 1972		<u>484.48</u>

Respectfully submitted, Myra L. Taylor, Treasurer

Audited by T. E. Pulley (19 May, 1973) & Harold D. Murray (2 June, 1973)

THE AMERICAN MALACOLOGICAL UNION, INC.

ACTIVE MEMBERS

Membership List revised October 27, 1973.

Abbott, Dr. and Mrs. R. Tucker, Delaware Museum of Natural History, Greenville, Del. 19807.
Abel, Richard & Company, Inc., P.O. Box 4302, Portland, Ore. 97208.
Adair, Mrs. Mary Lucy C., 2527 Loving Avenue, Dallas, Texas 75214 (Coloured or striped shells; *Murex*).
Aguayo, Dr. Carlos G., Dept. of Biol., Univ. of Puerto Rico, Mayaguez, Puerto Rico 00708.
Albert, Mrs. Ernest, 905 Bayshore Blvd., Safety Harbor, Fla. 33572.
Alexander, Robert C., 423 Warwick Rd., Wynnewood, Pa. 19096.
Allen, Dr. J. Frances, 7507 23rd Ave., Hyattsville, Md. 20783.
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Allen, Mrs. Lawrence K., Box 822, Port Isabel, Texas 78578 (*Murex*, *Pecten*, world marines; dealer).
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Bauer, Mr. & Mrs. Hugo C., 5205 Ave. 0-1/2, Galveston, Texas 77550 (All Mollusca).
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Bazata, Kenneth R., 430 Oldfather Hall, Univ. of Nebraska, Dept. of Zool., Lincoln, Neb. 68508 (Terrestrial pulmonates; *Dentalium*).
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- Clark, John W., Jr., Texas Archeological Salvage Project, Balcones Research Center, Rt. 4, Box 189, Austin, Texas 78757. (Economic exploitation of mollusks by prehistoric Indians, their use in ecological reconstruction).
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- Gilmour, Dr. Thos. H. J., Dept. Biol., Univ. of Saskatchewan, Saskatoon, Saskatchewan, Canada S7N 0W0 (Anisomyarian bivalves).
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- Glick, Dr. Robert N., 13500 E. 12 Mile Rd., Warren, Mich. 48093. (Cowries, cones, olives; beginners).
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Margaret C. Teskey
(Continued from page 2)

William J. Clench, Joseph C. Bequaert, Emery P. Chace, Katherine V. W. Palmer, Margaret C. Teskey, A. Myra Keen, The hononary life president, S. Stillman Berry, was first honored with life membership in 1954.

Attendance at the annual meetings averages about 25% of total membership. A program of diversified scientific papers has been followed from the beginning, though of recent years an effort is being made to group some of them into symposia. Conservation is being stressed, though to date the

effort to convince shell collectors not to take live mollusks seems confined to lip service. The World Health Organization's program of medical malacology, commercial interests served by research on behalf of the National Shellfisheries Association, promotion of mollusk-related science in schools and universities — all, together with many others, are being aided by the work of AMU. Also aided are untold numbers of people who love shells for their beauty alone. Truly, Norman Lermond builded better than he knew!

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IN MEMORIAM

Mrs. Dorothy Brown (1971)
 Hon. Thomas Desmond
 Rev. H. B. Herrington
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NOTICE

Most scientific journals send manuscripts to qualified reviewers to assist authors in avoiding errors and in improving their papers. The AMU has now adopted a similar policy. The AMU Council constitutes our review board and all manuscripts except abstracts are sent to appropriate members of this review board (usually two) prior to acceptance for publication.

The AMU Bulletin has also adopted as its standard the *Style Manual for Biological Journals* published by the American Institute of Biological Sciences, Washington. All manuscripts accepted for publication become the property of the AMU and may be edited for style in accordance with this standard.

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BULLETIN OF THE AMERICAN MALACOLOGICAL UNION, Inc.



1974



Fortieth Annual Meeting

THE AMERICAN MALACOLOGICAL UNION, INC.

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Published May, 1975

BULLETIN OF
THE AMERICAN
MALACOLOGICAL
UNION, Inc.



1974



Fortieth Annual Meeting

AMERICAN MALACOLOGICAL UNION FORTIETH ANNUAL MEETING

The 1974 meeting of the American Malacological Union was held in a setting of art, history, and science in the Museum Complex in Springfield, Massachusetts. The hard-working members of the Connecticut Valley Shell Club, under the leadership of their president, Earl Reed, were busy at the Registration Desk by 2:00 p.m. on Saturday, August 3, 1974, at Tolman Hall in the Museum of Science. Early arrivals gathered to greet old friends, make new ones, and have coffee and lemonade. Members of the local committee wore blue ribbons attached to their name tags and Executive Council Members wore red ribbons, a thoughtful touch provided by the CVSC Committee, which enabled everyone to identify those who might lend a hand in solving any problems which might arise.

Saturday night saw the early arrivals in gala attire, for it was the President's Reception, hosted by AMU President, Harold D. Murray, assisted by the members of the Connecticut Valley Shell Club. Slides taken by Myra Taylor at previous meetings were shown on a wall of the Museum, and members were surprised and amused to see themselves or friends in sober and sedate poses. A word of warning to those of you who may be tempted to arrive late at future meetings: next time come early so you will not miss out on any activities!

The Stonehaven Hotel, located just across the street from the Museum Complex, was the hub of activity for the members when not in the meetings. A map of the area, showing the locations of meetings and other activities, was posted on the bulletin board so that everyone could find just where all events occurred.

On Sunday morning the registration desk was again the scene of activity, when late arrivals were on hand to get name tags and talk "shells," before the meeting got under way.

In the afternoon, President Harold D. Murray called the meeting to order in the Museum of Fine Arts, and a cordial welcome was given by Chairman Earl Reed, on behalf of the City of Springfield, the Springfield Science Museum, and the Connecticut Valley Shell Club. After announcements, Harold thanked Mr. A.M. Frias Martins, photographer of the exquisite shell pictures exhibited in Tolman Hall, George Buckley and Walter Baranowski, who were projectionists for the meeting and Ruth D. Turner and Walter Baranowski who prepared the beautiful program cover. Excellent papers were then given

following the introductions, beginning with a commentary on America's first malacologist, Thomas Say.

The Conservation Committee met on Sunday evening, with Mrs. Jeanne Whiteside presiding. Among the many items of business of the Conservation Committee was the action to have the AMU enter a legal case involving Big Darby Creek in Ohio. This action required the expenditure of \$50.00. The action to intercede in the case was finally approved at the Annual Business Meeting but since the AMU Constitution and By Laws do not provide for disbursement of AMU Funds for such purposes the AMU membership was asked to contribute. Before the convention had adjourned, members had donated \$88.40 to the Conservation Committee for the legal action.

On Monday morning more papers were given, and the meeting was presided over by Don Moore. Members of the AMU assembled for the group picture just before lunch. In the afternoon the meeting was convened by Dorothy Beetle. Monday evening's program consisted of a movie, "Undersea Oasis," shown in the Museum of Science, while the members of the Executive Council met elsewhere.

Dorothea Franzen convened the meeting on Tuesday morning, and Gladys McCallum was in charge of the afternoon meeting. In the evening, Constance Boone was moderator for Shell Club Night, which consisted of a varied and interesting program beginning with a discussion by R. Tucker Abbott of "Preparing Exhibits and Judging Shell Shows," and an especially interesting program on *Melo amphora* given by Frank Abbottsmith, of Balga, Western Australia.

Following Shell Club Night, the Texas Delegation honored their Texas President, Harold D. Murray, with a party, to which all AMU members were invited. The Stonehaven Hotel very graciously donated a suite to the Texans for the party, but even so, guests overflowed the rooms and party-goers were to be found along the hallways. This Texas Party has by now become a tradition, and some of the guests were bidding the hosts good-bye at a very early hour in the morning. The Texan hosts were: Adelaide Johnstone, Corpus Christi; Constance Boone, Houston; Betty Allen, Port Isabel; Suzanne and Lloyd Pratt, Fort Worth; and Myra Taylor, San Antonio.

(Continued on page 79)

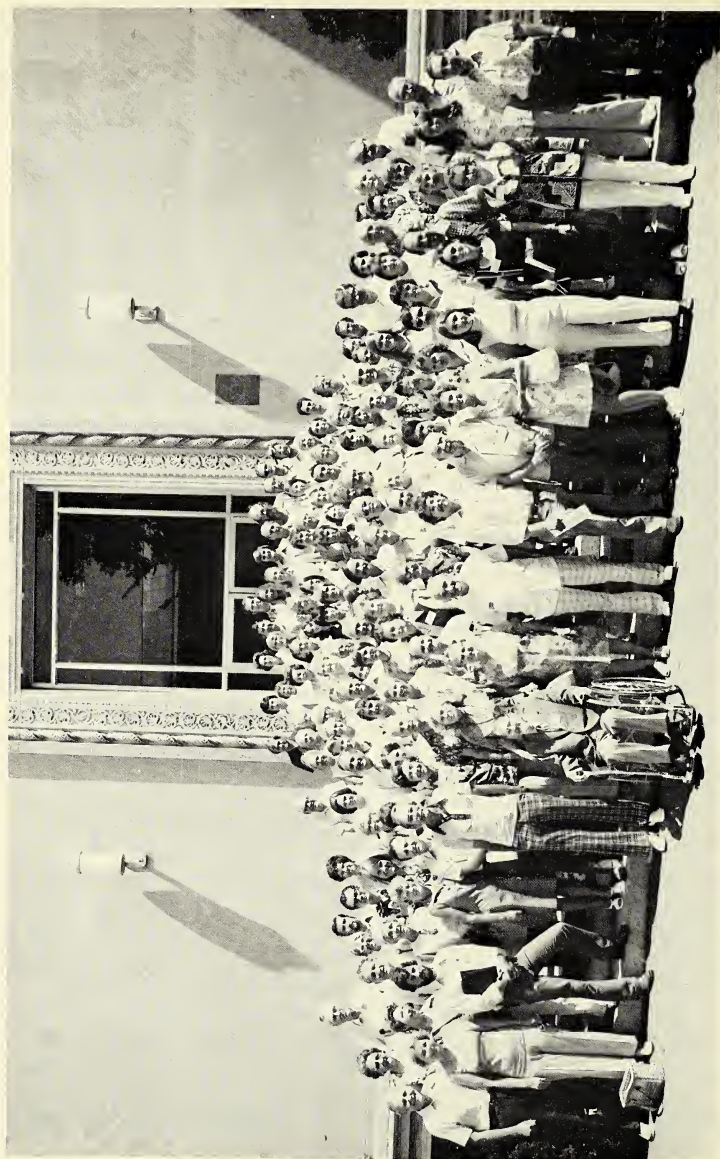
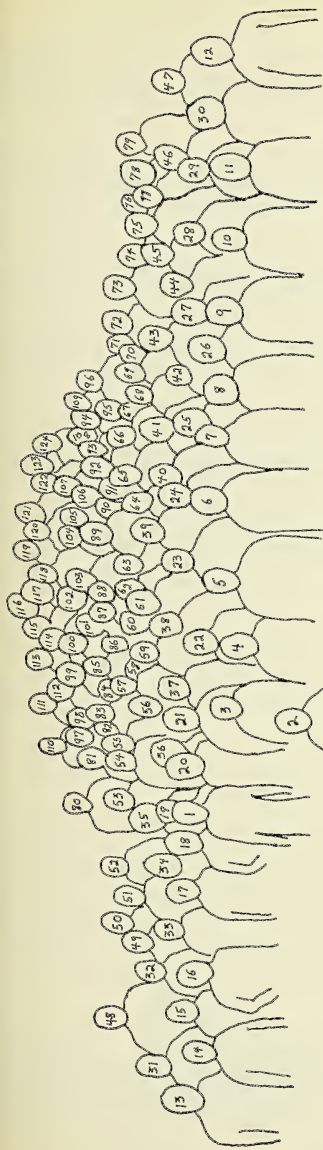


PLATE 1. MEMBERS AND GUESTS IN ATTENDANCE AT THE FORTIETH ANNUAL MEETING



Group photograph identification: 1 Harold D. Murray, 2 John D. Parker, 3 Kathleen D. Parker, 4 Esther Parodiz, 5 Morris K. Jacobson, 6 Samuel L.H. Fuller, 7 William J. Clench, 8 Gladys McCallum, 9 Olga J. Harasewych, 10 Dottie Janowsky, 11 Priscilla Bingham, 12 Earl Reed, 13 R.R. Cull, 14 Alice J. Cull, 15 Dorothy Raelhle, 16 Douglas G. Smith, 17 Mary Lois Stansbery, 18 David H. Stansbery, 19 Linda D. Saville, 20 Lois Rehder, 21 Harald Rehder, 22 Juan Jose Parodiz, 23 Corinne Edwards, 24 John McCallum, 25 Micki Fuller, 26 Kathleen K. Daniels, 27 Jerry Harasewych, 28 Robert Janowsky, 29 Jeanne Whiteside, 30 Avis Sosa, 31 Dorothea Frazen, 32 Albert Taxson, 33 Anne Taxson, 34 Kathy Gail Borror, 35 Bernadine Baker, 36 Sandra S. Sterrett, 37 Bonnie Oatis, 38 Helen King, 39 Adlai B. Wheel, 40 Hellen Nottter, 41 Dorothy Morrison, 42 Dorothy Beutle, 43 Anna Paine, 44 Dee Dundee, 45 Doris Ferguson, 46 Harriet Riggs, 47 Ralph Dexter, 48 Leslie Hubricht, 49 Myra L. Taylor, 50 David Bickel, 51 R. Tucker Abbott, 52 Marc J. Inlay, 53 Carolyn Jenkinson, 54 Emile Malek, 55 John Jenkinson, 56 Ellen McHugh, 57 Joseph Rosewater, 58 Jennifer Merrill, 59 Mary Rosewater, 60 Russell Jensen, 61 Mrs. A.B. Wheel, 62 Kenneth J. Boss, 63 James H. McLean, 64 Robert Talmadge, 65 Alan Solem, 66 Frank Kokai, 67 Norma Dexter, 68 Edwin G. Johnson, 69 Joseph F.E. Morrison, 70 Carol Stein, 71 Lloyd Pratt, 72 Frank Abbottsmith, 73 Hugh Porter, 74 Victor Scarabino, 75 John Ferguson, 76 Milton Werner, 77 Alice D. Barlow, 78 G. Barton Barlow, 79 Paul Jennewein, 80 Anthony Bagdon, 81 Patricia Bagdon, 82 Elaine Reed, 83 Nellie Dow, 84 Dorothy Meyer, 85 Mary Robert, 86 Percy Meyer, 87 Ella May Wuff, 88 Richard Honbrick, 89 Walter Baranowski, 90 Elaine Hoagland, 91 James M. Stitwell, 92 George Davis, 93 Adelaide B. Johnstone, 94 Kirk W. Anders, 95 Daniel Berezka, 96 Thomas C. Rice, 97 Henry B. Dow, 98 Ray Robert, 99 Constance Boone, 100 Betty Allen, 101 Roberta M. Curington, 102 Mathilde P. Weingartner, 103 Laureale Rappleye, 104 Glenn A. Long, 105 Henry D. Russell, 106 Juliette Compitello, 107 Susan F. Carnes, 108 Veronica Parker Johns, 109 A.M. Frias Martins, 110 Fred G. Thompson, 111 Marvin R. Hyett, 112 Mattie Chanley, 113 Leona Grantier, 114 Ruth D. Turner, 115 H. Wallace Roberts, 116 David Franz, 117 Carol Lalli, 118 Cynthia Moore, 119 George Buckley, 120 Donald R. Moore, 121 Arthur H. Clarke, 122 Arthur S. Merrill, 123 William K. Emerson, 124 Clyde F.E. Roper.

Registrants who attended convention but were not in photograph: Mrs. Ernest Albert, Mr. & Mrs. H.D. Atheam, Noorullah Babrakzai, John W. Barr, Jr., Lyle F. Chichester, Mr. and Mrs. John S. Dyer, Jr., D. Craig Edwards, John Gerner, F.W. Grimm, Mrs. Wm. W. Hughes, Jeanne Kuzirian, Alan M. Kuzirian, Hal Lewis, June Lunville, Lorna S. Melvin, M. Patricia Morse, Meyer Naide, Mrs. H. Wallace Roberts, Mary Ellen St. John, Isabelle Welch, M.E. Young.

PAPERS READ AT AMU 40th
ANNUAL MEETING

CYTOTAXONOMY OF SOME ARIZONA OREOHELICIDAE (GASTROPODA: PULMONATA)

Noorullah Babrakzai*, Walter B. Miller*, and Oscar G. Ward*.

Members of the land snail family Oreohelicidae were at one time placed in the Camaenidae as the subfamily Oreohelicinae by Pilsbry (1939). Later, Wurtz (1955) considered them sufficiently distinct from other Camaenidae to warrant familial rank. Bequaert and Miller (1973) concurred in this opinion. The family consists of the single genus *Oreohelix*, with two subgenera, *Oreohelix s. s.* and *O. (Radiocentrum)*. The two subgenera differ in their embryonic whorls, reproductive anatomy, and type of reproduction. *Oreohelix s. s.* is ovoviparous and has a reduced albumen gland, while *O. (Radiocentrum)* is oviparous and has a large albumen gland. The two subgenera are widely distributed in the western United States and northwestern Mexico (Bequaert and Miller, 1973).

Burch (1965) and Patterson (1969) reviewed the chromosome numbers and systematics in euthyneuran snails and other molluscs and discussed the importance of chromosome numbers and other cytological characters in molluscan systematics. Studies on Australian camaenids by Laws (1965, 1973), and on a Japanese camaenid by Inaba (1959) have shown that the chromosome number in the Camaenidae is $n=29$ without exception. It was, therefore, of interest to us to study the chromosomes of some Oreohelicidae to see how they would compare with those of the Camaenidae. In this communication we report the chromosome numbers of 6 species and the karyotypes of 4 species of Oreohelicidae.

MATERIAL AND METHODS

Live adult snails were collected from their type localities and identified by one of us (W.B. Miller). The following species were studied cytologically:

1. *Oreohelix (Radiocentrum) clappi* Ferriss, 1904, from South Fork of Cave Creek, Chiricahua Mountains, Cochise County, Arizona (three specimens).
2. *Oreohelix (R.) chiricahuana* Pilsbry, 1905, from Crystal Cave, Chiricahua Mountains, Cochise County, Arizona (twelve specimens).
3. *Oreohelix (Oreohelix) anchana* Gregg, 1953, from the Sierra Ancha, Gila County, Arizona (six specimens).
4. *Oreohelix (O.) concentrata* Dall, 1896, from Miller

Canyon, Huachuca Mountains, Cochise County, Arizona (seven specimens).

5. *Oreohelix (O.) subrudis* Reeve, 1854, from Greer, White Mountains, Apache County, Arizona (three specimens).

6. *Oreohelix (O.) houghi* Marshall, 1929, Mogollon Rim, near Pine, Gila County, Arizona (six specimens).

Mitotic and meiotic chromosome spreads of ovotestis tissue were obtained by the hypotonic squash technique (Babarakzai and Miller, 1974). Observations were made under a Wild compound microscope with 15x oculars and photomicrographs were taken on Kodak High Contrast Copy Film.

The nomenclature of centromeric position for the classification of chromosomes as proposed by Levan et al., (1964) has been followed in this study. The following symbols have been used in describing karyotypes:

- p, short arm of the chromosome.
- q, long arm of the chromosome.
- p+q, length of the chromosome.
- RL, relative length of chromosome expressed as percentage of the genome and multiplied by 10.
- q/p, arm ratio.
- CI, centromeric index, ratio of short arm to total length of chromosome, expressed as percentage.

A chromosome with arm ratio between 1.01 and 1.6 and CI (centromeric index) between 37.5 and 49.9 will be referred to as metacentric (*m*) chromosome. If the arm ratio is between 1.7 and 2.9, and CI is between 25.0 and 37.4, the chromosome is considered submetacentric (*sm*). Similarly a chromosome is considered subtelocentric (*st*), if the arm ratio is 3 or more and the CI is less than 25.0. For comparison of karyotypes, the methods of Bogart (1970) and Raicu et al., (1973) have been followed.

RESULTS

1. *Oreohelix (Radiocentrum) clappi*

We found only spermatogonial mitotic chromosomes from the specimens of this species. Chromosomal data are presented in Table I. The diploid chromosome number is 62 as seen in Fig. 1. Figure 2

* Department of Biological Sciences, University of Arizona, Tucson, AZ 85721.

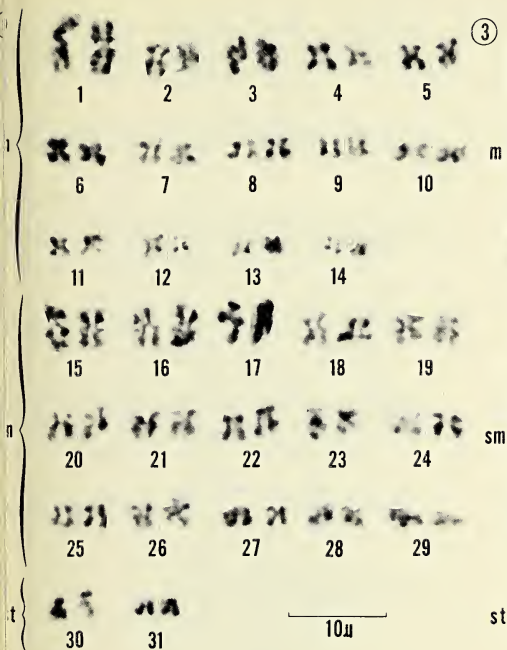


Fig. 1. Karyotype of *O. (R.) clappi*.

Fig. 2. Idiogram of *O. (R.) clappi*.

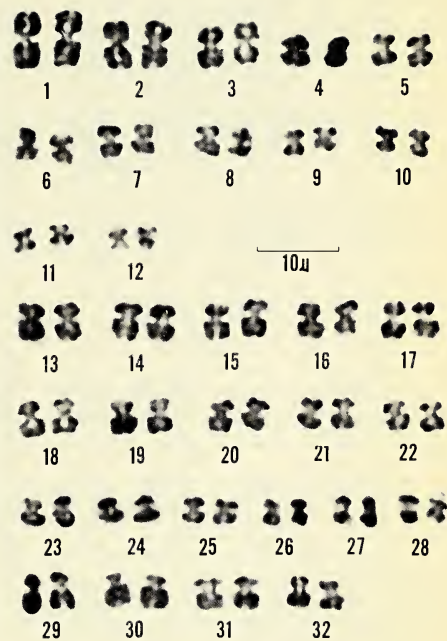
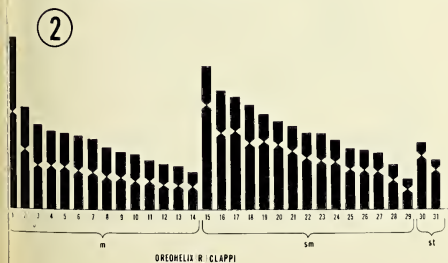


Fig. 3. Karyotype of *O. (R.) chiricahuana*.

Fig. 4. Idiogram of *O. (R.) chiricahuana*.

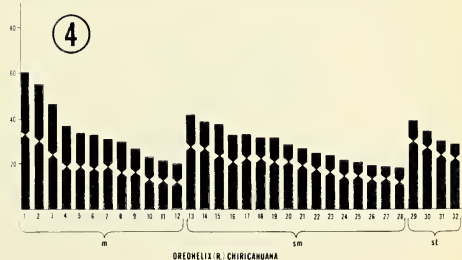
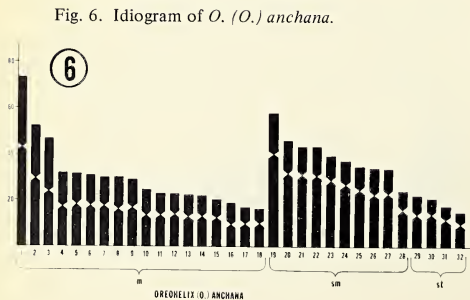
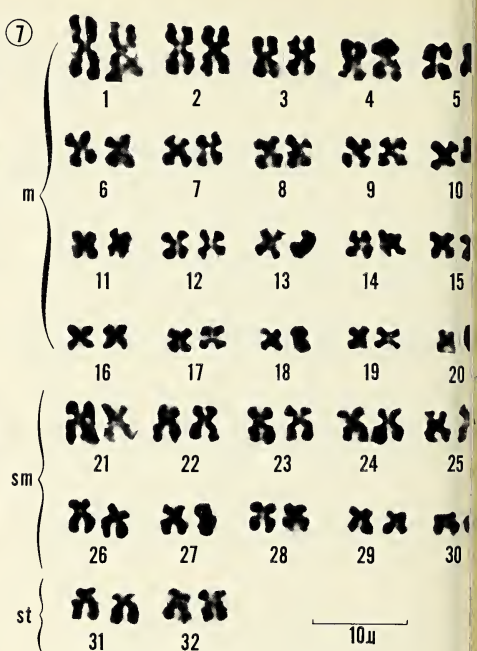
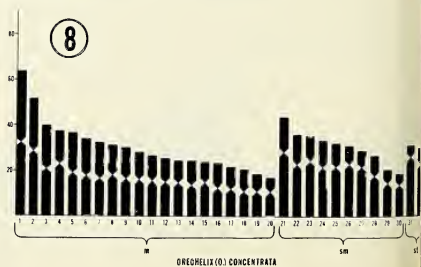
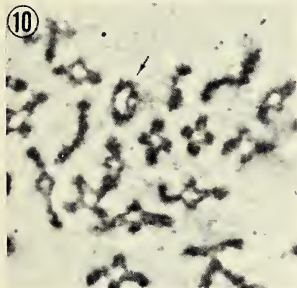


Fig. 5. Karyotype of *O. (O.) anchana*.Fig. 6. Idiogram of *O. (O.) anchana*.Fig. 7. Karyotype of *O. (O.) concentrata*.Fig. 8. Idiogram of *O. (O.) concentrata*.

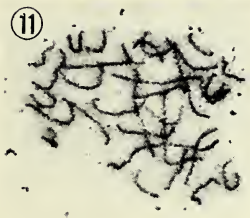
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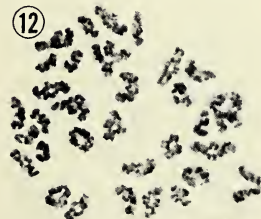
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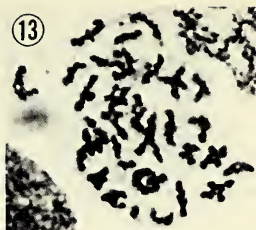
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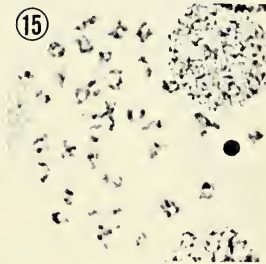
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14



15



16



Fig. 9. Diakinesis of *O. (R.) clappi*, arrow points to the quadrivalent.

Fig. 10. Part of diakinesis of *O. (R.) clappi* from another specimen, arrow points to the ring shaped univalent.

Fig. 11. Pachytene chromosomes of *O. (O.) anchana*.

Fig. 12. Diakinesis chromosomes of *O. (O.) anchana*.

Fig. 13. Diakinesis chromosomes of *O. (O.) concentrata*.

Fig. 14. Metaphase II chromosomes of *O. (O.) concentrata*.

Fig. 15. Diakinesis chromosomes of *O. (O.) subrudis*.

Fig. 16. Metaphase I chromosomes of *O. (O.) subrudis*.

shows an idiogram of the haploid set of chromosomes constructed from the data of Table I. *O. (R.) clappi* has 14 *m*, 15 *sm* and 2 *st* chromosomes. The largest chromosome is 7.3% of the entire genome.

2. *Oreohelix (Radiocentrum) chiricahuana*

The meiosis in this species seems to be complicated due to chromosomal aberrations. Meiotic chromosomes were obtained from only two specimens. One specimen had 30 bivalents and a quadri-valent (Fig. 9) at diakinesis, while another specimen had a ring shaped chromosome in addition to the haploid complement (Fig. 10). The ring shaped chromosome is apparently an isochromosome pairing with itself. Spermatogonial metaphase chromosomes were counted to be $2n = 64$ in a third specimen. The karyotype of *O. (R.) chiricahuana* (Fig. 3) has 12 *m*, 16 *sm* and 4 *st* chromosomes. Figure 4 shows the idiogram of the haploid set of *O. (O.) chiricahuana* based on the data in Table II. Neither meiosis nor mitosis was found in the rest of the 9 specimens; however, three carefully dissected specimens showed a characteristic anomaly in the reproductive anatomy. In all three, the hermaphroditic duct had no connection to the talon or fertilization chamber in the albumin gland, and these hermaphroditic ducts ended blindly, apparently rendering the individual snails sterile.

3. *Oreohelix (Oreohelix) anchana*

We obtained both mitotic and meiotic chromosomes. Thirty two bivalents were found in pachytene (Fig. 11) and diakinesis (Fig. 12) in many primary spermatocytes. The spermatogonial metaphases, without exception showed 64 chromosomes. Therefore the haploid number of *O. (O.) anchana* is $n = 32$ and the diploid number is $2n = 64$ (Fig. 6). The karyotype of *O. (O.) anchana* (Fig. 5) has 18 *m* and 14 *sm* chromosomes. The idiogram of this species is presented in Fig. 6, based on data from Table III.

4. *Oreohelix (Oreohelix) concentrata*

The haploid number of this species was determined from spermatogonial diakinesis (Fig. 13) and metaphase II (Fig. 14) to be $n = 32$. The diploid number is $2n = 64$ (Fig. 7). The karyotype of *O. (O.) concentrata* (Fig. 7) has 20 *m*, 10 *sm* and 2 *st* chromosomes. Figure 8 shows the idiogram of the haploid set of chromosomes, based on data from Table IV.

5. *Oreohelix (Oreohelix) subrudis*

Only meiotic chromosomes of this species were found. The haploid chromosome number is $n = 32$ in diakinesis (Fig. 15) and metaphase I (Fig. 16).

6. *Oreohelix (Oreohelix) houghi*

The haploid chromosome number in this species is $n = 32$ in diakinesis and metaphase I.

DISCUSSION

The chromosome numbers in Oreoheliciidae ($n = 31-32$) are quite different from those of the related family Camaenidae (Laws, 1973) in which the haploid chromosome number is $n = 29$ in 26 species studied so far. Cytological data also separate the

Oreoheliciidae from the Camaenidae. In the light of Burch's (1965) hypothesis that there is a progressive increase in chromosome number from more primitive families to specialized ones, Oreoheliciidae could be regarded as an advanced and specialized family of land snails. The chromosome numbers reported for helicean and polygyrean families are reviewed in Table V. From these data it is evident that the Oreoheliciidae have the highest chromosome number of all the families in the two superfamilies. The high number of chromosomes in one species of Polygyridae, *Triodopsis fraudulenta*, has been considered by White (1973) and Patterson (1969) to be due to supernumerary chromosomes.

The karyotypes of the four species are different, as shown in the idiograms (Figs. 2, 6 and 8). The idiograms of *O. (O.) anchana* and *O. (O.) concentrata* (Figs. 6 and 8) show differences in chromosome morphology, types, lengths, etc., even though chromosome number is the same in both species ($n = 32$). To derive one species from the other, one has to postulate many changes in the karyotypes of these two species, namely homozygous translocations and pericentric inversions. Several such changes have been observed by one of us in the land snail family Helminthoglyptidae (Babrakzai unpublished).

The difference in chromosome numbers between the two species of subgenus *Radiocentrum* ($n = 31$ or 32) and those of *Oreohelix s.s.* ($n = 32$) is also of interest. Particularly significant is the difference in karyotypes. *Oreohelix s.s.* has a majority of metacentric (*m*), while *Radiocentrum* has a majority of submetacentric chromosomes (*sm*). In view of anatomical and morphological differences already reported, we consider that *Radiocentrum* deserves full generic rank.

In plants, "catastrophic selection" and "saltational chromosomal speciation" have been proposed by Lewis (1962, 1966). Miller (1967, 1970 and 1973) and Bequaert and Miller (1973) have hypothesized that the same phenomenon is mainly responsible for speciation in desert snails (i.e., saltational speciation by major chromosomal rearrangements). The karyotypes of the four species of Oreoheliciidae of this report tend to support such a "saltational speciation" hypothesis. However, the interesting fact is that despite changes in the karyotype, i.e., chromosomal rearrangements, etc., the chromosome number usually remains the same.

The large number of anomalies in *O. (R.) chiricahuana* indicates a possibly high genetic load, probably brought about by intensive, continuous inbreeding. These snails are restricted to very small habitats consisting of widely scattered clumps of bear grass (*Nolina microcarpa*) on arid Upper Sonoran slopes in the Chiricahua Mountains. Gene exchange between populations in different bear grass clumps is probably infrequent. Accordingly, under such circumstances of excessive inbreeding, chromosomal aberrations become more frequent, and many of them are either lethal or prevent reproduction. The reduced number of reproductive survivors in the population would hasten genetic drift and tend to bring about saltational speciation.

Table I. Karyotypic data of *Oreohelix* (*Radiocentrum*) *clappi*.

No.	RL	q/p	CI	Classification
1	73.0	1.3	44.2	m
2	43.3	1.4	41.0	m
3	36.2	1.04	49.0	m
4	33.2	1.3	43.6	m
5	32.6	1.3	43.5	m
6	31.6	1.1	47.2	m
7	30.1	1.1	47.1	m
8	26.6	1.1	46.7	m
9	24.5	1.3	43.5	m
10	23.6	1.1	47.8	m
11	21.3	1.4	41.7	m
12	19.5	1.2	45.5	m
13	18.8	1.3	43.4	m
14	16.0	1.6	37.8	m
15	60.6	2.7	26.9	sm
16	50.4	1.8	35.2	sm
17	47.9	2.4	29.6	sm
18	44.3	1.8	36.0	sm
19	40.4	2.5	28.1	sm
20	37.6	2.8	26.4	sm
21	35.5	2.3	30.0	sm
22	32.6	2.1	32.6	sm
23	32.6	1.9	34.8	sm
24	29.4	2.3	30.1	sm
25	26.2	1.9	33.8	sm
26	25.2	2.1	32.4	sm
27	24.1	2.1	32.4	sm
28	19.5	1.9	34.5	sm
29	13.1	2.1	32.4	sm
30	28.7	4.2	19.8	st
31	21.3	3.9	20.0	st

Table II. Karyotypic data of *Oreohelix* (*Radiocentrum*) *chiricahuana*.

No.	RL	q/p	CI	Classification
1	61.4	1.2	46.2	m
2	55.4	1.2	45.8	m
3	46.4	1.1	48.2	m
4	36.8	1.04	48.9	m
5	33.8	1.3	44.4	m
6	32.9	1.2	46.6	m
7	30.8	1.6	39.0	m
8	29.9	1.2	45.2	m
9	26.9	1.6	39.0	m
10	23.3	1.4	42.5	m
11	21.6	1.4	41.7	m
12	20.1	1.5	40.3	m
13	41.3	2.0	33.4	sm
14	38.3	2.4	29.8	sm
15	37.4	1.8	36.1	sm
16	32.9	1.7	36.4	sm
17	32.9	2.1	31.9	sm
18	31.4	2.5	28.7	sm
19	31.4	2.0	33.4	sm
20	28.4	2.8	26.4	sm
21	26.9	2.6	27.9	sm
22	24.8	2.6	27.8	sm
23	23.9	2.2	31.3	sm
24	21.8	2.2	31.7	sm
25	20.9	2.5	28.7	sm
26	19.5	2.2	30.8	sm
27	18.9	2.7	27.0	sm
28	18.0	2.0	33.3	sm
29	38.9	3.2	23.1	st
30	34.2	3.6	21.9	st
31	29.9	4.0	20.0	st
32	28.4	3.7	21.1	st

Table III. Karyotypic data of *Oreohelix* (*Oreohelix*) *anchana*.

No.	RL	q/p	CI	Classification
1	73.1	1.4	41.9	m
2	51.8	1.3	42.7	m
3	46.4	1.04	48.9	m
4	31.8	1.1	46.6	m
5	31.2	1.4	41.9	m
6	30.6	1.4	41.9	m
7	29.6	1.5	40.0	m
8	29.6	1.1	46.7	m
9	28.6	1.4	41.4	m
10	24.1	1.3	42.6	m
11	22.7	1.6	39.1	m
12	22.5	1.6	37.7	m
13	22.1	1.5	40.2	m
14	21.7	1.4	40.9	m
15	20.0	1.6	37.6	m
16	18.7	1.1	47.4	m
17	16.8	1.4	41.2	m
18	16.2	1.6	39.0	m
19	57.3	2.3	31.0	sm
20	45.4	2.3	30.4	sm
21	42.5	2.6	27.9	sm
22	42.5	2.4	29.3	sm
23	38.7	2.7	27.0	sm
24	36.6	2.7	27.0	sm
25	34.0	2.4	29.1	sm
26	33.6	1.9	35.3	sm
27	33.2	2.1	32.7	sm
28	23.9	2.0	33.9	sm
29	21.7	1.8	36.4	sm
30	20.7	2.0	33.3	sm
31	17.4	2.9	34.1	sm
32	14.8	2.0	33.3	sm

Table IV. Karyotypic data of *Oreohelix* (*O*) *concentrata*.

No.	RL	q/p	CI	Classification
1	65.1	1.04	48.9	m
2	52.6	1.2	44.7	m
3	40.7	1.1	47.6	m
4	38.0	1.6	38.0	m
5	37.4	1.1	48.1	m
6	34.6	1.1	48.0	m
7	33.0	1.04	48.7	m
8	31.9	1.3	43.4	m
9	30.4	1.2	45.5	m
10	28.3	1.4	41.2	m
11	26.9	1.4	41.2	m
12	26.0	1.5	40.4	m
13	24.9	1.6	38.9	m
14	24.9	1.2	44.4	m
15	24.4	1.5	39.8	m
16	24.1	1.1	48.3	m
17	22.2	1.3	43.8	m
18	20.8	1.1	46.7	m
19	19.1	1.4	42.0	m
20	17.5	1.6	38.1	m
21	44.6	1.9	34.8	sm
22	37.1	1.8	35.8	sm
23	36.0	2.2	30.8	sm
24	34.1	1.8	35.0	sm
25	33.2	2.0	33.3	sm
26	31.9	2.8	26.1	sm
27	29.9	2.8	25.9	sm
28	27.7	1.9	35.0	sm
29	21.0	2.3	30.3	sm
30	19.4	2.5	28.6	sm
31	31.9	4.8	17.4	st
32	30.5	3.4	22.7	st

Table V. Chromosome numbers of Polygyracea and Helicacea: number of species for each family (after Laws, 1973).

Family (number of genera known cytologically)	Haploid chromosome numbers											
	21	22	23	24	25	26	27	28	29	30	31	32
Polygyridae (7) ¹						2			16	1(1)	(1)	
Camaenidae (15)									26			
Bradybaenidae (5)								9	8			
Helminthoglyptidae (9) ²									6	6		
Helicidae (19)	1	3	8	3	2	8	10		3	6(1)		
Oreohelicidae (2) ³											1	5

¹Babrakzai and Miller, 1974.²Babrakzai unpublished.³Present study.

CONCLUSIONS

We have drawn the following conclusions from these cytological findings:

1. The validity of separating the Oreohelicidae from the Camaenidae is substantiated cytologically (the haploid chromosome number of Camaenids is $n = 29$ in all species reported so far).
2. The Oreohelicidae have the highest chromosome number so far reported in the Helicacea.
3. All four species of *Oreohelix s. s.* have a haploid number of $n = 32$. Karyotypes obtained for only two of the species show small but significant differences which lend support for their specific separation heretofore based only on morphological characters.
4. Of the two species of *Radiocentrum*, one had a haploid number of $n = 32$ while the other had $n = 31$. Their karyotypes differed from each other only slightly but differed markedly from those of *Oreohelix s. s.*
5. The cytological evidence at hand indicates major chromosomal differences between species of *Oreohelix s. s.* and *Radiocentrum*. When added to the well-known differences in morphology and reproductive physiology, this evidence strongly suggests that *Radiocentrum* is sufficiently different from *Oreohelix s. s.* to be considered a separate genus. Accordingly, we hereby elevate *Radiocentrum* to full generic status.

6. The different haploid numbers of the two species of *Radiocentrum* along with their marked morphological differences suggest the possible existence of two species-groups or even subgenera under *Radiocentrum*. Additional karyotype investigations of species morphologically similar to *R. chiricahuana* such as *R. hachetana* and *R. ferrissi* and species similar to *R. clappi* such as *R. labrenana* would be desirable.
7. Differences in karyotypes indicate that speciation is accompanied (or accomplished) by substantial chromosomal rearrangement. This tends to support the hypothesis that speciation in many desert snail populations tends to be saltational by major chromosomal rearrangement.
8. A large number of reproductive anomalies found in *R. chiricahuana* indicates a possible high genetic load, which can be explained as a result of excessive inbreeding. This situation tends to intensify rapid genetic drift and promote saltational speciation.

ACKNOWLEDGMENTS

We are thankful to Richard Reeder, Carl Christensen and Peter D'elisqu for their help in collecting the specimens; to Dr. Joseph C. Bequaert for criticizing the manuscript; to Margaret Vescovi for illustrations and Sianoosh Babrakzai for her help in preparing the karyotypes.

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DORMANCY IN MOLLUSKS

Kenneth J. Boss*

Mollusks possess an extraordinary range of tolerances to environmental extremes. The ability to enter relatively inactive physiological states is probably mainly responsible for the far reaching exploitation of biotopes of gastropods and bivalves. Dormant or inactive stages may include aestivation during hot, dry periods or hibernation during the prolonged cold of winter. Dormancy is best documented among freshwater bivalves and terrestrial and aquatic gastropods, both prosobranch and pulmonate. Among pelecypods, several lineages have invaded freshwater and the unionaceans are the most numerous and successful. Species of North American, South American, Asiatic and African genera have been shown to withstand prolonged periods in stagnant waters and even months of aestivation in dried stream beds. A noteworthy example is a species of *Aspatharia* in East Africa which survives over the dry season embedded in desiccated mud amid clumps of dried aquatic vegetation; the species is capable of living for over 12 months without immersion in water.

Prosobranch snails possess an operculum which may tightly cover the aperture and seal the animal within its shell. Marine, freshwater and terrestrial prosobranchs utilize this structure when hibernating and aestivating. Littoral and supralittoral snails exhibit a graded series of adaptation in which the highest supralittoral species are capable of surviving the longest period out of water, upwards of 12 months. Some of the freshwater prosobranchs, similarly endowed, incline to crawl out of stagnant or inhospitable waters, attach to emergent vegetation, or burrow deeply into the substrate. The physiological events precipitating dormant behavior and facilitating its prolonged duration have been studied extensively among ampulariids. Terrestrial operculates tend to be mainly tropical or subtropical, possibly reflecting an evolutionary disinclination to tolerate the colder winters of the temperate and more polar zones. With a tightly closing operculum, terrestrial prosobranchs encountered problems with respiration, even though the consumption of oxygen is markedly reduced during aestivation. Several lineages of cyclophorids and neocyclotids have elaborated accessory shelly structures, such as tubes, pores and pipes, to facilitate contact between the aestivating animal and its external environment.

In contrast to the prosobranchs, the pulmonates, which normally lack the permanent and apparently rather impervious operculum, may, as the occasion arises, form an analogous structure, the epiphragm which can cover the whole of the aperture, assist in attaching the animal to a substrate and modulate gaseous exchange by its permeability or porosity. The basommatophoran pulmonates, being principally freshwater, burrow into the substrate (physids, lymnaeids and planorbids) or attach to the stems of aquatic vegetation (ancylids) during untoward weather. Some terrestrial forms (succineids) strongly attach themselves to trees during the rainy seasons and, in one case (a South American ancyloid), the animal may almost entirely close over the broad ventral aperture with a shelly matrix and form a cocoon. The cycle of activity for some cold temperate basommatophorans, especially forms in temporary forest pools, may be less than 30 days per year during which feeding and reproduction take place; the remainder of the year the animals remain dormant in the substrate.

Stylommatophoran pulmonates counter extremes of heat and cold by aestivating or hibernating with the aperture of the shell closed by an epiphragm. Frequently the dormant snail sequesters itself in a burrowed chamber with its aperture and epiphragm oriented upward. The slugs, lacking shells or having only reduced shells, may burrow deeply and form highly resistant cocoons. The stimuli initiating dormancy, the behavioral sequences leading to the formation of burrows, cocoons, and the like, as well as the complex physiological and biochemical events attending dormancy are best documented among stylommatophorans, especially the helicacean taxa.

The capability of enduring the exigencies of a rigorous physical environment plays an important role in the maintenance and expansion of geographic ranges of species and, by inference, probably has profound effects on the processes of evolution, including speciation and extinction. A thoroughly documented review of dormancy in mollusks has been published separately (Boss, 1974).

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ECOLOGICAL ASPECTS OF SOME MOLLUSCAN SPECIES OF PLEASANT BAY, ORLEANS, MASSACHUSETTS

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Pleasant Bay is largely undeveloped and unpoluted. It is approximately 3700 acres in water surface area at high tide, 2300 at low tide. The Bay's biological and physical characteristics are poorly known. The Bay is under ever increasing development and pollution pressures. The purpose of the ongoing study from which this paper was generated is to develop a data base of the physical characteristics of Little Pleasant Bay and to develop a faunal and floral survey.

The shellfisheries of the Bay yield a valuable harvest each year. Most of the proceeds from this harvest are received by local fishermen. There is little management of the resources of the Bay, largely because little is known about their reproduction and behaviour. The major organisms represented in the harvest are *Pecten irradians*, *Mercenaria mercenaria*, *Mya arenaria*, and *Busycon canaliculatum*. *Crassostrea* was once found in abundance but of late seed oysters have not set. There is talk of a *Mytilus* fishery, as in Spain but a pilot project will not be undertaken until next year at the earliest. The commercial and private harvesters have to compete with the abundant sea gulls which have been known to decimate localized populations of shellfish at low tide. *Linulus polyphemus*, the horseshoe crab has been wrongly accused of being a major shellfish predator. They prey only occasionally on young *Mya* and *Mercenaria*. Their importance in endotoxin research and the fact that they stir up the bottom by plowing for food thus increasing filtrant for bivalves outweigh their record as a predator. Their numbers are in decline in Pleasant Bay and thoughtless killing of them as predators has worsened the situation. *Polinices* and *Lunatia* are more serious predators and

although they prefer certain species in certain areas are actually fairly cosmopolitan in their diet. *Urosalpinx cinerea* is more abundant and predacious in the Bay than are the previous two species.

The populations of organisms discussed are surviving and indeed prospering in a unique environment. The vast, protected salt marshes provide ample breeding, hatching and growing facilities. Except for water temperature which frequently drops below freezing in winter and in July can average 23°C the physical environment is a reasonably stable one with pH of 7.8 and salinity of 2.6% average.

It is more than plausible that, given proper study and management, Pleasant Bay's yield could be greatly increased. A series of critical environmental choices must be made if this is to happen. The pressures for recreation, housing and industrial development are great. With these will come environmental change and possible harm to the shell fisheries. Development may provide more dollars but a greater percent of those dollars doubtless will not end up in the local economy and the shell fisheries dollars which for the most part do, will diminish with increased destruction of the environment. It is hoped that the iron law of the primacy of cash will not succeed in Pleasant Bay. Given the almost pristine nature of the Bay, such organizations as the Cape Cod Marine Science Center and the Association for the preservation of Cape Cod are seeking to enlighten people about the value of such a natural resource as Pleasant Bay. It is advisable to seek declaration of Pleasant Bay as a natural resource area under Coastal Zone Management regulations, which would limit commercial and recreational development, on and near the Bay.

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MOLLUSKS FROM SOUTHERN NICHUPTÉ LAGOON, QUINTANA ROO, MEXICO

Susan F. Carnes*

Vertical and horizontal changes in molluscan faunas recovered from eight soft-sediment cores from Nichupté Lagoon, Quintana Roo, Mexico permit recognition of four subenvironments and reflect the encroachment of a mangrove swamp onto the lagoon. Previously, Brady, (1971) analyzed these cores as part of a project describing the sedimentology of coastal lagoons on the northeastern Yucatan Peninsula. Sediments from the selected cores represent lagoonal, tidal delta, back lagoon marsh and mangrove swamp environments. Surface distribution of molluscan faunas in Nichupté Lagoon agrees with corresponding subenvironments and distribution of molluscan faunas in Florida Bay reported by Turney & Perkins (1972).

Some of the species commonly found in muddy lagoonal sediments include (in order of decreasing abundance):

Meioceras nitidum	C. floridanum
Tricolia affinis	Marginella denticulata
Bittium varium	Tegula fasciata
Modulus modulus	Menestho impressa
Cerithium eburneum	Pachystremiscus pulchellus
Zebina browniana	P. ornatus
Alvania auberiana	Rissoina bryerea
Acmaea pustulata	R. cancellata
Olivella dealbata	Chione cancellata
Granula lavalecana	Cardita floridana
Marginellopsis serrei	Cumingia tellinoides
Caecum pulchellum	Pinctada radiata
C. imbricatum	Anomia simplex

Tidal delta sediments contain a mixed fauna of lagoonal and open marine character.

Peaty sediments of the back lagoon marsh contain abundant sawgrass, mangrove and algal detritus. Mollusks found here include:

Potamopyrgus bakeri	Cerithidea costata
P. crystallina	Anomalocardia brasiliensis
P. coronatus	Pseudocyrena floridana

Mollusks common to both lagoonal and back lagoon marsh sediments include:

Retusa candei	Brachidontes exustus
Bulla striata	Gemma gemma
Crepidula spp.	Laevicardium mortoni
Prunum apicinum	

The lower portion of a 140 cm core (Brady's core 112) from the back lagoon marsh consists of sediments and fauna observed in the present-day lagoon. Overlying these lagoonal sediments are marsh sediments with fresh- and brackish-water mollusks. The upper portion of the core contains mud and peat that yields terrestrial gastropods including:

Truncatella bilabiata	Blauneria heteroclita
T. pulchella	Gastrocopta cf. G. servilis
T. caribaeensis	Melampus spp.
T. clathrus	

The vertical change in sediment type and molluscan fauna observed in this core documents the encroachment of the mangrove swamp into the lagoon.

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MOLLUSK UTILIZATION BY NOOTKA INDIANS, 2300 B.C. TO A.D. 1966

by Louise R. Clarke and Arthur H. Clarke*

INTRODUCTION

The Nootka are one of several mutually exclusive Indian nations which flourished between southern Alaska and northern California prior to the middle of the nineteenth century (see Drucker, 1963). Numerous radiocarbon datings of charcoal and shells have revealed that Yuquot, a presently existing Nootkan village on the central west coast of Vancouver Island, British Columbia (49°35'36"N, 126°37'06"W), may be the oldest continuously occupied settlement in North America. Little is known, however, about its history, or about the history of any Indian group in the whole region, prior to the first European contact 200 years ago.

To meet this lack, in 1966 the National Historic Parks and Sites Branch of Parks Canada carried out a meticulous and extensive archaeological investigation of the huge midden on which the present Indian village now stands.

The material excavated is now under study by a number of specialists but some preliminary general reports have already been published (Folan, 1969; Folan and Dewhirst, 1970). Detailed reports on the ethnohistoric aspects of the research will appear in the archaeological literature (e.g. see Clarke and Clarke, in press, for analysis of molluscan data) but it seems appropriate that a summary of the results regarding mollusks should be presented here.

MATERIALS AND METHODS

The excavation was done in a transverse area in the central part of the midden and to a maximum depth of 18 feet. Five foot grid squares, 30 in number, were laid out on the surface of the site. The material underlying each square was excavated in a series of numbered layers each six inches thick. Based on midden matrix characteristics, associated artifacts and radiocarbon dates four zones were recognizable in the midden. From top to bottom these zones and their ages are as follows: I, A.D. 1789 to 1966; II, A.D. 800 to 1789; III, 1000 B.C. to A.D. 800; IV pre-2300 B.C. to 1000 B.C.

After careful sorting, mollusks were found to be represented in 520 of the grid square levels and to

constitute 35% of the 96 cubic feet of faunal material which was recovered. Each shell and shell fragment was weighed and, when possible, identified. (In many Zone IV samples, however, the mollusks and bones were so compacted that accurate faunal analysis was impossible.)

RESULTS

The data generated are too voluminous to present here but a summary is given in Table 1. Numerical ratings reflect dominance within a zone, i.e. 1 indicates the most abundant species, 2 the next most abundant, etc. Species which occurred less than three times within a zone are designated by +. Absence is indicated by —.

CONCLUSIONS

In interpreting the significance of the chart it is important to note that the five species which head the list account for more than 90% of the mollusk remains found in the site both in terms of frequency of occurrence and in shell weight. The striking shift in dominance by epifauna (chiefly *Mytilus californianus* and *Nucella* (= "*Thais*") *lamellosa*) in Zones II, III and IV to dominance by infauna (*Saxidomus giganteus*, *Protothaca staminea* and *Tresus* (= "*Schizothaerus*") *nuttalli*) in Zone I (see Fig. 1) was probably caused by over-hunting and extinction of the local sea otter population about 1790 (Clarke and Clarke, in press). Sea otters consume marine invertebrates, including clams, in large quantities (Kenyon, 1969) and where sea otters exist in dense populations they exert profound effects on the intertidal and subtidal marine invertebrate communities (Estes and Palmisano, 1974).

All of the species found in the excavation occur alive in British Columbia at the present time (Bernard, 1970; Rice, 1972). Since no unquestionably exotic species are present there is no evidence on that score that climatic changes have taken place.

Other evidence which may indicate climatic changes is meager. *Natica clausa* was found eight times in Zone III, it was absent from Zone II, and was found 11 times in Zone I. This is a wide-ranging cold

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Table 1. Relative Abundance of Marine Molluscs Within Zones

Species	Zones			
	I	II	III	IV
<i>Saxidomus giganteus</i> Deshayes	1	3	3	3
<i>Protothaca staminea</i> (Conrad)	2	4	4	4
<i>Mytilus californianus</i> Conrad	3	1	1	1
<i>Tresus nuttalli</i> (Conrad)	4	5	6	5
<i>Nucella lamellosa</i> (Gmelin)	5	2	2	2
<i>Katharina tunicata</i> (Wood)	6	8	+	+
<i>Tegula funebralis</i> (A. Adams)	7	10	11	—
<i>Astraea gibberosa</i> (Dillwyn)	8	6	5	—
<i>Nucella canaliculata</i> (Duclos)	9	7	7	—
<i>Clinocardium nuttalli</i> (Conrad)	10	+	—	—
<i>Hinnites multirugosus</i> (Gray)	11	11	8	—
<i>Acmaea mitra</i> Rathke	12	—	—	—
<i>Natica clausa</i> Brod. & Sby.	13	—	9	—
<i>Glycymeris subobsoleta</i> (Carp.)	14	+	—	—
<i>Tegula pulligo</i> (Gmelin)	15	+	+	—
<i>Nucella lima</i> (Gmelin)	16	+	—	—
<i>Cryptochiton stelleri</i> (Midd.)	17	12	—	—
<i>Calliostoma ligatum</i> (Gould)	18	—	—	—
<i>Searlesia dira</i> (Reeve)	19	13	12	—
<i>Polinices lewisii</i> (Gould)	20	9	10	—
<i>Nucella emarginata</i> (Deshayes)	21	+	—	—
<i>Pododesmus machroschisma</i> (Desh.)	22	—	—	—
<i>Spisula falcata</i> (Gould)	23	—	—	—
<i>Diodora aspera</i> (Rathke)	24	—	—	—
<i>Olivella boetica</i> (Marrat)	25	+	—	—
<i>Littorina sitkana</i> Philippi	+	+	+	—
<i>Crepidula adunca</i> Sowerby	+	+	—	—
<i>Crepidula nummaria</i> Gould	+	+	—	—
<i>Monilopsis incisa</i> (Carp.)	+	+	—	—
<i>Dentalium</i> sp.	+	—	—	—
<i>Notoacmaea scutum</i> (Rathke)	+	—	—	—
<i>Colisella digitalis</i> (Rathke)	+	—	—	—
<i>Crepidula lingulata</i> (Gould)	+	—	—	—
<i>Ceratostoma foliatum</i> (Gmelin)	+	—	—	—
<i>Oenopota reticulata</i> (Brown)	+	—	—	—
<i>Humularia kenneblyi</i> (Reeve)	+	—	—	—
<i>Panopea generosa</i> (Gould)	+	—	—	—
<i>Pseudochama exogyra</i> (Conrad)	—	+	—	—
<i>Crassostrea gigas</i> (Thunberg)	+	(top)	—	—
Total species	39	22	18	6

water species and its absence from Zone II may imply a warmer period throughout that time. The presence of *Pseudochama exogyra* (one find) only in Zone II give some support to this tentative interpretation. *P. exogyra* now occurs from Panama to Oregon and as a disjunct population in the Queen Charlotte Islands.

In general the material indicates that, except for the period from 800 to 1789 A.D. which may have been slightly warmer, the climate on the outer coast of Vancouver Island probably has not changed significantly during the past 3000 years, and possibly for more than 4000 years. Research on postglacial climates in western Canada, using data from tree ring and mountain glacier studies, provides some support for this conclusion (e.g. see Rampton, 1971). The records presented also document the presence of the

species concerned on the central west coast of Vancouver Island for significant periods of past time.

This research was supported by Parks Canada and by the National Museum of Natural Sciences, both agencies of the Government of Canada. The material reported here is stored in the Mollusc Unit of the National Museum of Natural Sciences, National Museums of Canada.

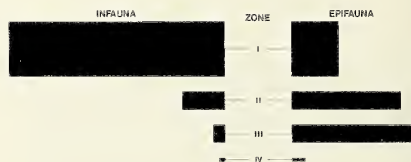


Fig. 1. Relative abundance of infauna and epifauna within zones. Bar areas are proportional to shell weights. See text.

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PREFERRED PREY OF *POLINICES DUPLICATUS* IN CAPE COD INLETS

D. Craig Edwards*

A fundamental aspect of any animal's ecological niche is its feeding relationships, including not only the range of foods eaten but also the preferred sizes and kinds. Food preferences are critical in determining the impact of a predator on (a) a prey population and the stability of their interaction (MacArthur, 1955; Murdoch, 1969) and (b) community structure (Paine, 1966; Harper, 1969). Feeding data are of particular interest for a species like *Polinices duplicatus* which preys on commercially valuable bivalves such as *Mya arenaria* (Hanks, 1952) and *Mytilus edulis* (Hanks, 1960) as well as other mollusks important as food for bottom fishes. This report on the diet and preferred prey of *P. duplicatus* summarizes information obtained during long-term, ongoing studies of the ecology of New England's naticid gastropods.

In the Cape Cod area *P. duplicatus* is near its northern geographic limit (Miner, 1950; Hanks, 1960) and is subject to as extreme annual and daily variations in seawater temperature as any known (Sanders, 1968, 1969; Green and Hobson, 1970). Moreover, here, in contrast to lower latitudes, the snail is often restricted to the intertidal sand flats of bays and harbors, being replaced near true mean low water and below by *Lunatia heros* (cf. Hanks, 1952). In such a "physically controlled" regime, a few generalist species with broad niches might be expected to dominate higher trophic levels (Sanders, 1968).

Although supplementary observations were made at Wellfleet Harbor (Lieutenant Island) and Nauset Marsh (channels), the main study site was a 200 x 200 m area of sand flat at Barnstable Harbor (Indian Trail access). Extending from a salt marsh to the vicinity of an eelgrass bed, the site encompassed the vertical range of *Polinices*, though *Lunatia heros* occurred in the lower 100 m (see Gilbert, 1973, for beach profile and sediment data). From 1968 to 1973 direct field observations on foods and sizes of prey taken by different sizes of predators were made by first excavating buried snails and ascertaining what, if anything, they were eating and then measuring both predator and prey. The best procedure was to lift snails gently from below, but, even so, many retracted quickly into their shells, releasing any prey. The criteria for feeding were: (a) prey held firmly in

the snail's foot or wrapped in a substantial mucus sheath and/or (b) prey's shell etched or bored, but not devoid of fresh tissue. The few cases of unbored snails carrying prey wrapped in a posterior fold of the foot were used; simple excavation of a probable prey with a snail, however, was insufficient.

An indication of the relative abundance of alternative prey in the study area was obtained from high-to-low shore transect sampling, taking either 62.5 cm² cores (1.5 mm sieving mesh) or 1/4 to 1/2 m² quadrats (3 mm mesh) to 10-15 cm depths. Each April (1969-72) 20 cores and 2-8 m² of quadrat samples were taken. In 1969, 12 m²/4 quadrats from the upper 100 m of the area (where *Lunatia* rarely occurred) were analysed for both live and dead (bored + unbored) prey; and, in 1970, in a subarea (adjacent to the upper 50 m of the transects) where *Mya* briefly flourished, 16 m²/4 samples were examined for *Polinices* and *Mya* (live and dead). Stratified-random sampling designs were used.

Naticids distinctively mark their prey with bore holes, but the percentage of empty shells so marked is, although sometimes used for these purposes, a poor indicator of either feeding rates (Green, 1968; Edwards and Huebner, in prep.) or prey preferences. Other predators destroy (e.g. crabs), remove (man, birds, fish), or leave mollusk shells to the actions of currents and hermit crabs; whereas *P. duplicatus*, by burrowing to feed, "deposits" even surface-dwelling prey. Probably for such reasons, the majority of all empty shells taken in 1969 were bored (Table 1) The proportion is even greater, if special cases are omitted. *Gemma* numbers thousands per m² (cf. Green and Hobson, 1970) and is eaten by newly settled snails (Turner, 1951; Hanks, 1960), but is too small to be adequately sampled by my methods; whereas *Ensis* is eaten, but not drilled. Excluding these species, the overall value was 3/4ths bored, whether for all bivalves, all gastropods, or the three best-sampled species of each or both. Similarly, in 1970, 70% of 619 empty *Mya* were bored. The percentage of bored shells may then be as high for less preferred prey as for the greatly preferred *Mya* (see below). The experimentally verified food list of *Polinices* (Table 1) is a minimal one, since additional potential molluscan prey were available in exceptional years.

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Table 1

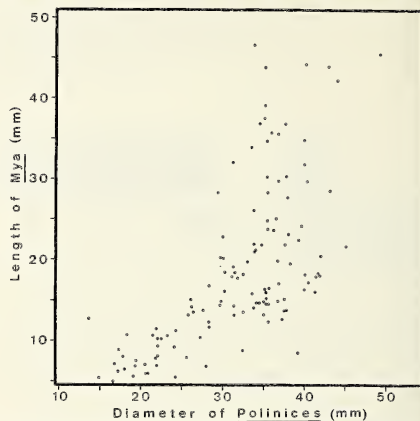
Empty shells of prey species taken in 1969 ($\Sigma N = 1757$)

Species	N	% bored	Sizes bored $\bar{x} \pm SD$ (mm)
Bivalves			
<i>Mya arenaria</i>	137	78	10 ± 5
<i>Mytilus edulis</i>	27	30	38 ± 11
<i>Mercenaria mercenaria</i>	37	100	11 ± 7
<i>Tellina agilis</i>	3	0	—
<i>Spisula solidissima</i>	7	71	10 ± 2
<i>Lyonsia hyalina</i>	1	0*	—
<i>Ensis directus</i>	5	0*	—
<i>Gemma gemma</i>	586	15*	< 3
Gastropods			
<i>Littorina littorea</i>	912	75	9 ± 4
<i>Nassarius obsoletus</i>	23	74	9 ± 6
<i>Polinices duplicatus</i>	17	76	10 ± 2
<i>Lunatia heros</i>	1	100	8
<i>Nassarius trivittatus</i>	1	100	11

* See text for details.

In direct field observations (Table 2) 222 *Polinices* (13-49 mm shell diam.) were taken attacking 12 species of prey (4-121 mm shell length). Coverage of ~1 year and older snails was adequate, with sampling bias favoring larger, more evident ones. Very small snails were harder to locate and, owing to their tactile sensitivity, especially difficult to excavate without loss of food items. Diets usually reflected fluctuations in prey populations, but several feeding preferences

were evident. First, large *Polinices* generally ate larger and more variable sizes of prey than small ones (Table 2; Fig. 1). On a species-specific basis, there were significant correlations (nonparametric tests) between the

Fig. 1. The positive association ($p < 0.001$) between the sizes of predators and their *Mya* prey ($N=124$)

sizes of predators and two of the prey, *Mya* ($p < 0.001$) and *Mytilus* ($p < 0.01$). Available *Mya*, mainly new young, however, limited size-selection, for in experimental studies (Edwards and Huebner, in prep.)

Table 2

Attacks on each prey species: % per time or place; total numbers; and sizes of animals

Barnstable Harbor site							
General area							
Species	<i>Mytilus</i> present 1968-69	<i>Mytilus</i> absent 1970-72	<i>Mya</i> subarea 1969-70	Other sites 1970-73	Total numbers 1968-73	Sizes (mm)*	
						Prey x̄ ± SD	Predator x̄ ± SD
Bivalves							
<i>Mya arenaria</i>	43	41	92	17	124	19 ± 10	32 ± 8
<i>Mytilus edulis</i>	28		4		18	35 ± 13	37 ± 6
<i>Tellina agilis</i>	2	22		14	18	8 ± 2	24 ± 6
<i>Mercenaria mercenaria</i>	6	4	1	3	7	17 ± 6	31 ± 8
<i>Spisula solidissima</i>	6	2			4	9 ± 3	29 ± 7
<i>Ensis directus</i>		4	1	3	4	50 ± 51	27 ± 10
<i>Lyonsia hyalina</i>		7			4	8 ± 2	22 ± 7
Gastropods							
<i>Littorina littorea</i>	7	17	1		14	17 ± 5	29 ± 6
<i>Nassarius obsoletus</i>	4			63	24	17 ± 1	35 ± 4
<i>Nassarius trivittatus</i>	2	2			2	13 ± 1	18 ± 1
<i>Lunatia heros</i>	4				2	16 ± 1	38 ± 5
<i>Polinices duplicatus</i>		2			1	21	33
Total attacks	54	54	79	35	222		
Total species	9	9	5	5	12		

* Kendall's coefficient of rank correlation between unrounded mean sizes of predators and prey yielded $p = 0.075$ for all 12 comparisons or $p = 0.05$ for the 6 best-sampled ones.

larger prey were preferred (e.g., the relationship between predator (X) and prey sizes (Y) was $Y = 12.23 + 0.64 X$ ($N=377$) for snails offered a surfeit of 1-year old *Mya*). Similarly, although the sizes of *Polinices* and *Tellina* were not significantly associated ($p < 0.10$), the snails selectively attacked the largest of these small clams (cf. Gilbert, 1973). Second, feeding under differing food regimes ("natural experiments") indicated preferred species of prey. Two obvious changes occurred at Barnstable: during the winter of 1969-70, *Mytilus*, previously an abundant, larger prey, vanished from the sand flats; and in 1969 and 1970 only, and just in one small subarea, sizable (> 25 mm) year-old *Mya* were numerous. Prior to the first change the strong dominance and 1,2 rank of *Mya* and *Mytilus* in the snails' diet (Table 2, col. 1) directly reflected prey abundances. Allowing for size factors favoring *Mytilus* in feeding observations, there was no evidence for a preference between these bivalves. With the loss of *Mytilus*, feeding shifted toward *Tellina* and *Littorina*, increasing the diet's evenness while maintaining its species diversity (Table 2, col. 2). *Mya*, with highly variable annual recruitment, alternated with *Tellina* for top rank in abundance; its continuing dominance in the diet implied a preference, though size factors would also favor *Mya* over *Tellina*. *Tellina* (like the vanished *Mytilus*) was more numerous downshore. The larger, but heavy-shelled, *Littorina* was ubiquitous, never plentiful, but always ranked at or near third in abundance. *Nassarius trivittatus*, numerous in 1970-71, and *N. obsoletus*, always present in moderate numbers, were under-represented in the diet of *Polinices*. With the second change in feeding regimes, *Mya*, now available in preferred sizes as well as dominant in numbers, truly monopolized a low-diversity diet (Table 2, col. 3). Even when *Mytilus* was present (1969), *Mya* constituted 90% of the diet. Indeed, *Polinices*, including tagged ones, were attracted to the *Mya* sub-area: Huebner (1972) took 1.4 and 2.2 snails per m^2 in 1969 and I took $1.5/m^2$ in 1970. In contrast, densities were $0.4-0.7/m^2$ in the general area, and Russell Hunter and Grant (1966) found $0.6/m^2$ in another nearby area. The "natural experiments" thus indicated *Mya* as the preferred species of prey. At other sites (Table 2, col. 4) the only unusual feature was the feeding on *Nassarius obsoletus*, which represented all of the observations at the Wellfleet site in 1970. By itself such a pure diet might suggest a preference, but, given the Barnstable findings, it is more likely that *Nassarius* is a low-ranking prey taken when better alternatives are lacking.

Two experimental studies further clarified feeding patterns. The apparent preference between the high-ranking *Mya* and *Mytilus* prey was tested by first training 7 snails (31-33 mm) on each pure diet for 80 days in field cages and then providing each predator with a 5 *Mya* (~22 mm) vs 5 *Mytilus* (~28 mm) choice situation in laboratory aquaria provided with sand and seawater. The training period alone showed *Polinices* grew significantly faster on a *Mya* diet. In the preference test, training had very little effect and all snails adopted a pure *Mya* diet within 15 days (Table 3). When size differences are not great, *Mya* is

Table 3

Attacks on *Mya* and *Mytilus* ($\Sigma N = 426$) in a prey-preference test. Although 7 predators had been trained on each diet, both groups preferred *Mya*. The preference increased with time.

Training diet	Days 1-5		Days 6-10		Days 11-15	
	N	% <i>Mya</i>	N	% <i>Mya</i>	N	% <i>Mya</i>
<i>Mytilus</i>	52	87	64	95	86	99
<i>Mya</i>	64	95	73	96	87	100

clearly the greatly preferred prey. Feeding on *Nassarius obsoletus* and *N. trivittatus*, very similar, apparently low-ranking prey, was comparably tested. Eight *Polinices* (32-35 mm), half from the tidal level where each prey was common, were kept in individual field cages stocked with 15 of each nassariid. Prior co-existence did not affect feeding, which initially was minimal; over a period of 25 days *N. trivittatus* was preferred 41 to 6. Next, 2 *Polinices* (32-33 mm) were trained on each pure diet for 64 days and then each predator was offered a 5 *N. trivittatus* vs 5 *N. obsoletus* choice situation for 10 days. During training the *N. trivittatus* diet was the more popular (42 eaten vs 10), and only on it was growth appreciable. In the preference test, predators preferentially ate the low-ranking prey upon which they had been trained, favoring either *N. trivittatus* 6:1 or *N. obsoletus* 4:0. The untrained predator's preference for *N. trivittatus* is probably related to the defensive behavior of *N. obsoletus*. When *Polinices* contacts *N. obsoletus*, the latter, which exhibits little of the twisting, "leaping" predator-avoidance response of other nassariids, extends its proboscis and "bites" the massive foot of the intruder. Normally both then depart, but if the prey is captured it continues to bite its captor, even as the latter wraps its victim in its mesopodium and burrows into the substrate. Perhaps in response, *Polinices* wraps this prey, as it does *Ensis*, in an especially heavy mucus sheath.

Within the restriction of complete dependence on molluscan prey (Edwards and Huebner, in prep.), *Polinices duplicatus* is indeed a dominant, generalist predator in the Cape Cod area, eating at minimum all 13 regularly available mollusks of the Barnstable site, and occurring in unusual abundance (nearly $1/m^2$) for a high-level consumer. Feeding patterns, however, are complex. *Polinices* exhibits strong preferences for prey both by size and species. Moreover, as in other marine invertebrates (Landenberger, 1968; Murdoch, 1969), training has little effect and dietary switching is unlikely when the most-preferred prey is available; whereas the effects of feeding experience and the prospects for switching increase when only low-ranking prey occur. Yet even predation on systematically and ecologically similar species involves distinctive behavioral interactions.

ACKNOWLEDGMENT

This work was initiated with support from the Univ. of Mass. Research Council and aided by the Dept. of Zoology. Graduate ecology classes helped with transect sampling. John Jenkinson, via the NSF-URP program, and Gary Norman assisted in feeding tests with *Nassarius*. As a Visiting Investigator in the Systematics-Ecology Program (M.R. Carriker, Director), I benefited from the facilities of the Woods Hole (Mass.) Marine Biological Laboratory.

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THE VALUE OF ANATOMICAL CHARACTERS IN NAIAD TAXONOMY (BIVALVIA: UNIONACEA)¹

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Study of the anatomy of Nearctic naiades began with the descriptions and illustrations incorporated in Lea's "Observations on the genus *Unio*" (1834-1874). Lea's notes lay unexploited until Simpson, notably in his "Synopsis of the naiades, or pearly fresh-water mussels" (1900), coupled some of them with his own discoveries and created the first naiad classification to be based in large measure upon anatomical data. Commencing with his "New system of the Unionidae" (1910), Ortmann contributed a long series of papers which developed an anatomically based naiad system that not even the best later re-evaluation (i.e., Heard and Guckert, 1971) could radically alter.

Although the value of anatomical information in naiad systematics has been generally recognized, there have been oddly few attempts (e.g., Ortmann, 1917; Kraemer, 1970; Fuller, 1971) to use such knowledge taxonomically — i.e., in discrimination between and among species. This paper is intended to show how anatomical discriminants can be employed to separate conchologically similar and/or congeneric species.

Most naiad specimens available to early investigators had been immersed alive in preservative. Such material exhibits adequately preserved anatomical features of *systematic* value (e.g., the marsupium), but the inner lobe of the mantle margin, where lie most details of pigmentation and form that are of *taxonomic* value, is so badly contracted and shrunken that full and accurate observation is not possible. However, if a mussel is relaxed and fixed before storage in alcohol, the delicate, contractile margin can be preserved in a nearly or quite lifelike aspect, whereupon sound observations can be made.

We have chosen three pairs of at least nominally congeneric species to illustrate the kinds of valuable information that can be gained from properly preserved naiad material. Unless otherwise credited, the notes below have not previously been published, insofar as we are aware.

Our first pair of congeners is *Lampsilis teres* (Rafinesque), the Yellow Sand Shell, widespread in the Interior Basin and Gulf drainages, and *L. fasciola* (Rafinesque) of the Basin. The latter represents the advanced members of its genus: the postbasal inner mantle lobe is an extensively pigmented "flap" of

piscine form. On the outer surface of the lobe, pigment is rather dark and solid along the distal margin, including the flap, and forms longitudinal streaks on the proximal portion. There is a very dark "eyespot" at the posterior end of the flap, and over the anterior part (or "tail") pigment is opalescent, giving the appearance of the scales of a fish. These patterns are greatly reduced on the inner surface of the lobe.

In *Lampsilis teres* there are some conspicuous differences from *L. fasciola* in both form and pigmentation of the postbasal mantle margin. The longitudinal streaks on the inner lobe are very faint, and the band along the distal margin of the lobe is very narrow. There is no eyespot. Although the lobe is very broad postbasally, development of a flap is limited to additional broadening of the lobe in the region where the tail of the flap occurs in *L. fasciola*. Finally, pigmentation is usually limited to the outer surface of the lobe, but on the inner surface some specimens have a broad orange band along the distal margin. Is the presence or absence of this band merely a polymorphic phenomenon, or, perhaps, does it hold promise as a discriminant between *L. teres* and a very similar nominal species, *L. fallaciosa* 'Smith' Simpson, the Slough Sand Shell?

These data suggest that *Lampsilis teres* is less advanced than *L. fasciola* and that reconstruction of the evolutionary history of this genus is possible on the basis of anatomical evidence. Improved taxonomic understanding should follow. For example, we have a preserved male of the rare *L. binominata* Simpson of the Apalachicola river system in the eastern Gulf drainage. There is a faint eyespot, which would doubtless be more conspicuous were the specimen a female. This species is surely an advanced member of its genus.

The shells of *Lampsilis teres* and *L. fasciola* are quite distinct, so anatomical information is not necessary for the separation of these species. Nevertheless, the profound differences between their anatomies reflect the potential of this kind of information in separating conchologically similar species. Kraemer (1970), for example, demonstrated that several Interior Basin *Lampsilis* are separable according to characters of their mantle flaps. Similarly, the flap of

1 Portions of this study were supported by the Department of Limnology at the Academy of Natural Sciences of Philadelphia; others, by National Science Foundation grant GB-40064.

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L. ochracea (Say) is "greatly reduced" (Fuller, 1971), whereas *L. cariosa* (Say) has a strongly developed flap.² Thus the separation of these two conchologically confusing species (which are restricted to the Atlantic drainage, where they sometimes occur together) not only is easy on the basis of anatomical observation, but also can be done from living material, thereby obviating the need to remove any specimens from a struggling population for identification purposes (see Fuller, 1971).

Our second pair of congeners is *Villosa delumbis* (Conrad) and *V. vibex* (Conrad). Both occur in the southern Atlantic drainage; the latter, in the eastern Gulf drainage as well. Pigment of the outer surface of the inner lobe along the postbasal mantle margin is dark and rather solid in *V. delumbis* and ends abruptly a short distance anterior from the incurrent mantle aperture. This pattern allies this species with *V. lienosa* (Conrad) of the Gulf drainage, but is quite different from the pigmentation of *V. vibex*, which consists of dark streaks, extends the length of the animal, and includes an eyespot. In all three respects, this pattern is typical of advanced *Lampsilis*. There is no mantle flap, but, especially in older females of *V. vibex*, there is strong papillation in the region where the tail of the flap occurs in advanced *Lampsilis*. On the basis of such evidence, plus the observations (above) on *L. teres*, should we consider that *Lampsilis* and *Villosa* are distinct genera, congeneric subgenera, or worthy of separation at all?

Our first two sets of examples provide new information, to be sure, but create unresolved problems as well. The third example demonstrates that some taxonomic problems can be at least partially solved with anatomical evidence. Endemic to the Choctawhatchee river system in the eastern Gulf drainage, *Elliptio mcMichaeli* Clench and Turner has darkly pigmented mantle apertures, and most papillae of the inner row at its incurrent aperture are weak versions of the arborescent incurrent papillae (Lea, 1860) that are characteristic of the Margaritiferidae (*sensu* Heard and Guckert, 1971) and, in varying degrees of development, of many Nearctic Unionidae: Ambleminae (i.e., the Amblemididae of Heard and Guckert). It is generally accepted that these two groups are less advanced than the Unionidae: Unioninae (*sensu* Ortmann, 1910, but minus tetragenous genera), to which *E. mcMichaeli* belongs. Accordingly, the presence of even weakly arborescent papillae in this species persuades us that it is primitive within its genus.

Now, Johnson (1970) considered *Elliptio mcMichaeli* a synonym of *E. fraterna* (Lea) of the Savannah river system in the southern Atlantic drainage and, presumably (*ibid.*), of the Choctawhatchee and the neighboring Apalachicola and Ochlock-

onee systems to the east. However, the mantle margins of *E. fraterna* are only faintly pigmented, and its incurrent papillae, conspicuously fewer than those of *E. mcMichaeli*, are simple or bifid. We interpret these characters as clearly in advance of the corresponding features of *E. mcMichaeli*. Thus it appears that these two conchologically similar species of *Elliptio* not only are easily separated on anatomical grounds, but also are of two different evolutionary grades within their genus. This line of inquiry does not guarantee that there is no prior objective synonym for either species, but it does demonstrate that they are not synonyms of each other.

2 Morrison (1975) states that *Lampsilis ochracea* has no flap and belongs in the genus *Leptodea*. Recently collected and better preserved than Fuller's (1971), our material also shows that no flap exists. This alone does not prove that the species is a *Leptodea*, but, nevertheless, Morrison may be quite correct.

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SPECIATION WITHIN THE *TRIODOPSIS FALLAX* GROUP
(PULMONATA: POLYGYRIDAE) —
A PRELIMINARY REPORT

F. Wayne Grimm*

INTRODUCTION

The genus *Triodopsis* s.s. (Family Polygyridae) is an explosively evolving group of land snails which is confined to humid eastern North America. A closely related subgenus, *Cryptomastix*, which exhibits similar patterns in the evolution of its species, occurs in western North America. Members of the genus *Triodopsis* may be found in many habitats in eastern North America, from the humid boreal forests at the tops of the higher Appalachians, through the southern hardwoods and swamps, to the semiarid post oak savannahs of the south-central United States. Species and individuals are most numerous in the deciduous and mixed forests of the southern Appalachians. They usually live on the ground under leaf-litter, logs, or stones and emerge from their retreats at night to feed upon fungi or dead plant tissue. In the mild climate of the southern Atlantic and Gulf coastal plain they are active from late fall to late spring, and aestivate in summer. Inland, and in cooler climates, they hibernate from two to five months of the year and are active through the spring and summer. During their active periods, particularly in the early spring, they deposit clutches of four to ten eggs in loose soil beneath some cover. The young hatch in from two to three weeks and most reach maturity in six to eight months. The adults live from two to four years in the laboratory, and deposit eggs at irregular intervals, the shortest interval noted between clutches being three weeks and the longest six months. Although they are hermaphroditic, they do not self-fertilize. They mate repeatedly and often, although one mating seems to be enough to fertilize a snail for at least a year, if not for its lifetime.

Most of the work which has been done on the systematics of this genus at the species level by Pilsbry (1940), Hubricht (1950a,b; 1952a,b; 1953; 1954; 1958; 1971), and Vagvolgyi (1968) has been based upon morphology of the shell. Pilsbry (1940) and Webb (1952; 1954; 1959) have illustrated and discussed the anatomy of a few members of the genus in the course of more comprehensive studies. To date, no publications exist which correlate the shell morphology, internal morphology of the genitalia,

the ecology, behavior, and distribution of these animals. The taxonomy of this genus must be based upon all of these factors taken together, because, as Hubricht (1953) and Vagvolgyi (1968) have shown, forms which have strikingly dissimilar shell morphology often interbreed. My own work is showing that some forms which have similar shells belong to different species groups anatomically and genetically. *Triodopsis juxtidentis juxtidentis* (Pilsbry), *Triodopsis anteridon* Pilsbry, *Triodopsis fallax hopetonensis* (Shuttleworth), *Triodopsis cragini* Call, and *Triodopsis claibornensis* Lutz resemble each other quite closely, but are more closely related to other species than to each other.

Thirty-one named forms in *Triodopsis* s.s. are based on shell morphology. Often, poorly sampled, isolated populations have formed the basis upon which the taxonomy of the genus is based. Vagvolgyi (1968), by studying only the shell morphology of many small and few large population samples taken from several places within the ranges of the named taxa and constructing character indices, reduced the total number of recognized taxa to sixteen, and described a new subspecies.

Over a period of about ten years I have managed to collect, breed, and dissect most of the named taxa within the subgenus, but most of the hybridization experiments were interrupted or terminated by moving my place of residence and the colonies about. Therefore, this paper is devoted to the one species group within the genus which I think I understand, and includes a few observations of other groups which may differ from those of previous workers. The aim of this paper is also to arouse interest in this group of snails so that the enormous gaps in our knowledge may be filled.

DESCRIPTION OF THE GENUS, ITS SUBGENERA,
AND SPECIES GROUPS WITHIN *TRIODOPSIS*
SENSU STRICTO

In this work, the genus *Triodopsis* Rafinesque, 1819 is being taken in the broad sense (Pilsbry, 1940) to include polygyrid land snails in which the lower portion of the penis is enveloped by a thin muscular

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sheath which is connected to the retractor muscle by a retractor muscle. The spermathecal duct is muscular and is expanded conspicuously, and the interior chamber of the penis is papillose. This genus comprises a diverse group of animals. Each of its three subgenera is fundamentally distinctive, but the genus itself possesses traits common to other members of the triodopsine Polygyridae: the penial sheath and the expanded spermathecal duct. For this reason, a good case can be made to elevate these subgenera to the level of genera (Webb, 1952; 1954; 1959). This step requires a complete anatomical revision of the Polygyridae, a task too large to be discussed here. For informative discussions of polygyrid systematics at the generic level, consult Pilsbry, 1940, and Webb, 1952, 1954, 1959.

Although examination of both the shells and the genitalia of triodopsine snails usually indicates the species group to which they belong, the anatomical differences between members of the same subgenus often appear negligible. In fact, most of the smaller species in *Triodopsis* s.s., although they differ in size and arrangement of penial papillae, can and do inseminate each other in the laboratory. Unless inseminated by another individual, *Triodopsis* will not oviposit. Eggs resulting from cross insemination by members of different species groups do not hatch.

SUBGENUS *Xolotrema* Rafinesque, 1819:425, type *Triodopsis denotata* (Férussac) = *T. notata* (Deshayes) designated by Pilsbry, 1940: 823.

This subgenus is characterized anatomically by possessing a verge through which the vas deferens opens into an ejaculatory pore (Webb, 1952: 7-8; 1954: 16). It includes two sections: *Xolotrema* s.s., which comprises *Triodopsis denotata* (Férussac, 1821) and its allies, and *Neohelix* Von Ihering, 1892, which comprises *Triodopsis albolabris* (Say, 1816) and its allies. All shells have a closed umbilicus.

SUBGENUS *Cryptomastix* Pilsbry, 1939: XVII; 1940, 852-853, type *Triodopsis mullani olneyae* (Pilsbry, 1891).

This western subgenus is characterized anatomically by possessing a well differentiated epiphallus terminating in a short, vestigial flagellum. There is no verge, and the penis contains two major ridges of papillae and several minor ones. Recent collecting in the northwestern U.S. has suggested to me that the relationships between members of this subgenus are at least as complex as those between eastern *Triodopsis* s.s., if not more so.

SUBGENUS *Triodopsis sensu stricto* Rafinesque, 1819: 425, type *T. lunala* Rafinesque = *Helix tridentata* Say, 1817.

This subgenus is characterized anatomically by possessing a penis-chamber which contains several converging rows of papillae and bears no verge or stimulator. The vas deferens is not thickened to form a conspicuous epiphallus, and there is no flagellum. The shell is umbilicate and usually possesses three apertural teeth. The other characters are as defined for the genus. This subgenus contains several species groups which may be defined on the basis of a combination of shell characters, genital characters, and

genetic affinity (determined by breeding experiments in the laboratory, coupled with observed hybridization in the field).

I have been unable to assign all named species to groups, as breeding experiments have been terminated without completion in many cases, and cases of parallelism are common.

The following species-groups are now recognizable in *Triodopsis* s.s.:

1) The *Triodopsis tridentata* group, characterized by having an ovate-triangular aperture with a marginal lip-swelling and pointed, widely spaced lip teeth. *Triodopsis tridentata* (Say, 1817), *Triodopsis tennesseensis* (Walker and Pilsbry, 1902), *Triodopsis complanata* (Pilsbry, 1898), *Triodopsis platysayoides* (Brooks, 1933) and *Triodopsis burchi* Hubricht, 1950, belong to this group. I have collected *Triodopsis tridentata* with all species in this group except *T. complanata* and have observed no hybridization. An anatomical description of the group is being prepared.

2) The *Triodopsis fraudulentula* group, characterized by having a penis with a widely expanded apical chamber and a narrow stalk. *Triodopsis fraudulentula* (Pilsbry, 1894) and *Triodopsis anteridon* Pilsbry, 1940, definitely belong to this group, as these species were found interbreeding at several stations in Greenbrier County, West Virginia, and pure populations were crossed in the laboratory. By shell characters, several other species may belong to this group, but they have not been studied.

3) The *Triodopsis juxtidentis* group, characterized by having the upper and lower lip teeth close together, and by having a high, straight parietal tooth which points at or above the upper lip tooth. The extended penis differs from that of *T. tridentata* by having larger, more widely spaced papillae and by having a more receding ejaculatory pore and a narrower stalk. Shells of several samples resemble *T. anteridon* very closely, but that species interbreeds with *Triodopsis fraudulentula*. *Triodopsis juxtidentis*, *Triodopsis tridentata*, and *Triodopsis fraudulentula* have been found together many times without showing signs of interbreeding. The *Triodopsis juxtidentis* group comprises *Triodopsis juxtidentis juxtidentis* (Pilsbry, 1894) and *Triodopsis juxtidentis discoidea* (Pilsbry, 1904). I found intermediate populations in the New River gorge near Hinton, West Virginia, and Vagvolgyi (1968: 173) found similar populations farther downstream in Clay Co., West Virginia.

4) *Triodopsis vulgata* Pilsbry, 1940, which is characterized anatomically by a penis which has approximately twenty rows of tiny papillae (compared with the usual five to eight) and a terminal ejaculatory pore, appears to be somewhat isolated. It is possible that some of the species which have not been assigned to a group are related to this one. Pilsbry's (1940: 807) description of the specimen from Wilmington, North Carolina applies to *T. juxtidentis*. This unique species has been considered by Pilsbry (1940: 805) to be a subspecies of *Triodopsis fraudulentula*, and by Vagvolgyi (1968: 175) to be a subspecies of *T. neglecta*. Webb (1959: 24-38) illustrated the genitalia

of both *T. neglecta* and *T. vulgata*, showing that despite the similarity of their shells, the species are quite different.

5) The *Triodopsis cragini* group, characterized anatomically by having a greatly elongated, threadlike penis and by having the expansion of the spermathecal stalk some distance above its base (Figure 3,c). This group includes *Triodopsis cragini* Call, 1886, *Triodopsis vultuosa* (Gould, 1848), and *Triodopsis henriettae* (Mazyck, 1877). Although shells of members of this group are difficult to separate from some members of the *Triodopsis fallax* group, the unique genitalia show that this group is isolated. Members of this group interbreed occasionally.

6) The *Triodopsis fallax* group is characterized genetically. All of the taxa produce fertile hybrids in the laboratory when deliberately crossed with each other,

and many, but not all of them cross in the field. None cross with members of other groups. Although these forms vary in penial papillation, they all apparently possess a concentrated group of comparatively large papillae in the apical chamber of the penis. This character does not separate them from several other members of *Triodopsis* s.s., however. The shells of these snails vary greatly, but they possess no shell characters which differentiate them collectively from other groups in the subgenus, although each taxon within the group is distinct. This group includes *Triodopsis fallax fallax* (Say, 1825), *Triodopsis fallax obsoleta* (Pilsbry, 1894), *Triodopsis fallax messana* Hubricht, 1952, *Triodopsis fallax vannostrandii* (Bland, 1875), *Triodopsis fallax hopetonensis* (Shuttleworth, 1852), *Triodopsis fallax alabamensis* (Pilsbry, 1902), and *Triodopsis soelneri* (J.B. Henderson, 1907).

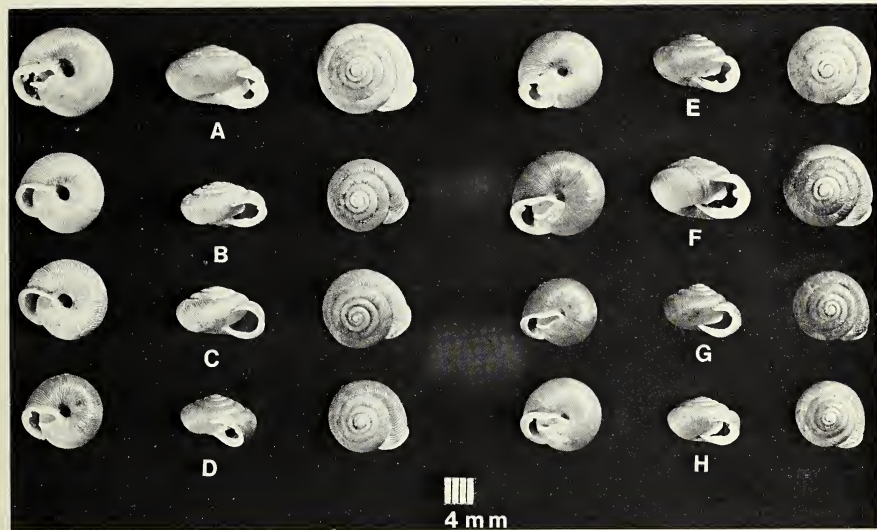


Figure 1. The *Triodopsis fallax fallax* complex. Shells.

- A. *Triodopsis fallax fallax* (Say) NMC 63190. Milford, Baltimore Co., Maryland. F.W.G.!
- B. *Triodopsis fallax obsoleta* (Pilsbry) NMC 59884. New Bern, Craven Co., North Carolina. Leslie Hubricht! TOPOTYPES.
- C. *Triodopsis fallax obsoleta* (Pilsbry) NMC 59894. Leon (Pig Point), Anne Arundel Co., Maryland. F.W.G.!
- D. *Triodopsis fallax fallax* X *Triodopsis fallax obsoleta*. NMC 60535. Chincoteague, Accomack Co., Virginia. F.W.G.! TOPOTYPES of *Triodopsis hopetonensis chincoteaguensis* Pilsbry.
- E. *Triodopsis fallax messana* Hubricht NMC 59862. Whiteville, Columbus Co., North Carolina. Leslie Hubricht, PARATYPES.
- F. *Triodopsis fallax messana* Hubricht NMC 59869. Nichols, Marion Co., South Carolina. F.W.G. & W.A. McDonald!
- G. *Triodopsis soelneri* J.B. Henderson NMC 95880. North Shore Lake Waccamaw, Columbus Co., North Carolina. F.W.G.! TOPOTYPES.
- H. *Triodopsis soelneri* X *Triodopsis fallax messana*. NMC 59878. Creek embankment, Bladenboro, Bladen Co., North Carolina. F.W.G. & W.A. McDonald!

Members of the *Triodopsis fallax* complex range from the piedmont of Pennsylvania and New Jersey southward on the piedmont and coastal plain to northern Florida and westward on the Gulf coastal plain to eastern Alabama. In isolated places, members enter and cross the Appalachians, and to many places outside their natural ranges the anthropochorous members have been introduced by man.

Triodopsis fallax has produced populations which occupy several degrees of intermediacy between being full species and races of the same species. Although several of these populations fail to interbreed when they contact each other, all of them interbreed readily with *Triodopsis fallax fallax* in the laboratory, and many of them interbreed with it in the field. The following seven populations may be clearly distinguished on the basis of shell morphology, habitat preference, and geographic range.

Triodopsis fallax fallax herd. Figure 1.

This is the northern herd of populations. When dentition is reduced, the aperture becomes sharp-edged, and the lip swelling is retained only on the inner, ventral edge of the lip. Members of this herd readily interbreed when in contact with each other, as a rule. *Triodopsis soelneri* retains its identity even when in contact with the closely related *Triodopsis fallax messana*, however. Hybrids between these two populations are extremely rare.

Triodopsis fallax fallax (Say, 1825) Figure 1:A; Figure 3:B

COLOR light buff brown; SCULPTURE finely striate; SPIRE medium domed; WHORLS 4.5 - 5.0; UMBILICUS medium to narrow; LIP EDGE sharp dorsally, swollen ventrally; UPPER LIP TOOTH very large, rounded, always inflected; LOWER LIP TOOTH large, buttressed on columellar side; PARIETAL TOOTH large, high, arcuate; FULCRUM present; LUSTRE dull; RANGE piedmont and coastal plain New Jersey to central Virginia, piedmont and eastern Appalachians to northern Georgia; HABITAT thin upland woods, clearings, roadsides. Anthropochorous.

Triodopsis fallax messana Hubricht, 1952 Figure 1: E,F

COLOR dark red brown to walnut brown; SCULPTURE very finely striate; SPIRE medium domed; WHORLS 4.5 - 5.0; UMBILICUS narrow to barely perforate; LIP EDGE sharp; UPPER LIP TOOTH large, rounded to pointed, flush with lip, or sometimes inflected; LOWER LIP TOOTH large, buttressed on columellar side; PARIETAL TOOTH large, high, arcuate; FULCRUM absent; LUSTRE shining; RANGE coastal plain, inland near Miocene terrace, eastern North Carolina and South Carolina; HABITAT pine woods, low hardwood stands, cypress swamps, roadsides. Anthropochorous.

Triodopsis fallax obsoleta (Pilsbry, 1894) Figure 1: B,C Figure 3: A, a

COLOR dark red brown to walnut brown; SCULPTURE coarsely to finely striate; SPIRE low domed; WHORLS 4.5 - 5.0; UMBILICUS medium to wide, funicular; LIP EDGE sharp; UPPER LIP TOOTH

medium to absent, pointed, rarely inflected; LOWER LIP TOOTH small to medium, usually buttressed if larger than 0.2 mm.; PARIETAL TOOTH small, low, slightly arcuate; FULCRUM absent; LUSTRE shining; RANGE outer coastal plain, pleistocene to holocene land from Maryland to northeastern South Carolina. Rare in the southern portion of its range. HABITAT low woods, marshes, roadsides, clearings. Anthropochorous.

Triodopsis soelneri (J.B. Henderson, 1907) Figure 1: G

COLOR dark red brown; SCULPTURE finely striate; SPIRE medium domed; WHORLS 4.5 - 5.0; UMBILICUS barely perforate; LIP EDGE sharp, inner edge swollen; UPPER LIP TOOTH obsolete, rarely present as a tiny swelling; PARIETAL TOOTH large, low, arcuate; FULCRUM absent; LUSTRE shining; RANGE small area between Lumber and Cape Fear Rivers on outer coastal plain in far southeastern North Carolina; HABITAT low woods, pine woods.



Figure 2. The *Triodopsis fallax alabamensis* complex. Shells.

- A. *Triodopsis fallax alabamensis* (Pilsbry) NMC 59834. Wooded Hillside 5 miles south of Wetumpka, Elmore Co., Alabama. Leslie Hubricht!
- B. *Triodopsis fallax vannostrandii* (Bland) NMC 59841. Allendale, Allendale Co., South Carolina. F.W.G.!
- C. *Triodopsis fallax hopetonensis* (Shuttleworth) NMC 59858. Whiteville, Columbus Co., North Carolina. F.W.G. Found with the type population of *Triodopsis fallax messana* Hubricht, without intergradation.
- D. *Triodopsis fallax fallax* X *Triodopsis fallax alabamensis* NMC 59842. Columbia, Richland Co., South Carolina. Leslie Hubricht! PARATYPES of *Triodopsis fallax affinis* Hubricht.

The *Triodopsis fallax alabamensis* herd. Figure 2.

This is the southern herd of populations. When dentition is reduced, the aperture usually retains a swollen edge. The teeth usually stand out more conspicuously from the aperture than they do in the previously discussed examples. The parietal tooth often is more abrupt, its inner edge quite low, its outer edge high and sharp. They hybridize readily with *Triodopsis fallax fallax* in nature, as well as with each other, but they hybridize with other members of the northern herd only if isolated in the laboratory with them.

Triodopsis fallax alabamensis (Pilsbry, 1902)

Figure 2:A

COLOR light buff to light red brown; SCULPTURE coarsely striate; SPIRE high to medium domed; WHORLS 5.5 – 6.5; UMBILICUS wide, well-like, sometimes medium; LIP EDGE usually swollen; UPPER LIP TOOTH large, rounded, sometimes inflected; LOWER LIP TOOTH large, buttressed; PARIETAL TOOTH short, high, straight or with curved remnant; FULCRUM usually absent; LUSTRE dull; RANGE western North Carolina and south-western Virginia to eastern Alabama; HABITAT open, mesic woods, roadsides.

Triodopsis fallax vannostrandi (Bland, 1875)

Figure 2:B

COLOR light buff; SCULPTURE coarsely striate, SPIRE high to medium domed; WHORLS 5.5 – 6.5; UMBILICUS narrow; LIP EDGE swollen; UPPER LIP TOOTH large, rounded, inflected; LOWER LIP TOOTH large, buttressed; PARIETAL TOOTH short, high, straight or arcuate; FULCRUM absent; LUSTRE dull; RANGE south-central South Carolina to northern Florida, west to eastern Alabama; HABITAT pine barrens, pine woods, clearings, low ground when within the range of *alabamensis* (Hubricht, pers. comm.).

Triodopsis fallax hopetonensis (Shuttleworth, 1852)

Figure 2:C

COLOR dark walnut brown; SCULPTURE medium to coarsely striate; SPIRE low domed; WHORLS 4.5 – 5.0; UMBILICUS medium to wide; LIP EDGE usually swollen, sometimes sharp; UPPER LIP TOOTH medium to large, rounded to slightly pointed, inflected; LOWER LIP TOOTH medium to large, buttressed; PARIETAL TOOTH medium to large, high, curved, often short; FULCRUM absent; LUSTRE dull; RANGE southern Atlantic and Gulf coastal plain from southeastern Virginia to Florida, west to Alabama, with introduced populations outside of its range in Tennessee, Mississippi, Alabama, the piedmont of Virginia, and New Jersey. This is the most synanthropic member of the *fallax* complex, being found in cities, along roadsides and in dumps. In southern North Carolina, eastern South Carolina, and eastern Georgia it is found in the woods, on barrier islands behind sand dunes, and in other "natural" situations. Outside of this area it is usually synanthropic. It crosses readily with *Triodopsis fallax fallax* and with other members of the southern herd, but is reproductively isolated from members of the northern herd in nature, but not in the laboratory.

As can be seen from the descriptions, most of the shell characters used to distinguish the taxa intergrade, but not evenly. Each of these nominate, morphologically distinct populations has a specific geographic and environmental range, and large samples collected from "natural" habitats such as woods, marshes, and swamps are remarkably homogeneous. In a few places, scattered, homogeneous intermediate populations exist, but these are rare and may be the product of introgressive hybridization in the distant past. Some populations of *Triodopsis fallax obsoleta*, particularly when the lip teeth have been enlarged by introgression from *messana* or *fallax*, are difficult to distinguish from *hopetonensis*. The lip of the aperture is a bit thinner in large toothed *obsoleta*, and the color of the shell a bit more reddish than in *hopetonensis*. Both Leslie Hubricht (1958; pers. comm.) and I have found easily distinguishable populations of *obsoleta* and *messana* living with *hopetonensis* without intergradation. *Hopetonensis* does cross with the others in the laboratory, however, producing fertile hybrids. Perhaps this is due to restricted choice of mating partners and withdrawal of seasonal climatic and photoperiodic changes.

Hybridization is quite common between certain members of this complex in urban areas and on waste ground. I have seen no cline anywhere. Wild hybrid swarms seem to be quite rare. I know of only two, and one appears to be largely the result of human activity and partially the result of natural causes. On the Delmarva Peninsula, east of Chesapeake Bay, *Triodopsis fallax fallax* occupies the northern half of the peninsula, and a multitude of colonies of hybrids between it and *obsoleta* occupy the southern half. Each colony appears to be quite uniform, occupying some stable stage of intermediacy between the two. There is no cline. One of these colonies was given the name *Triodopsis hopetonensis chincoteaguensis* Pilsbry, 1940: 813. Some colonies resemble *Triodopsis fallax hopetonensis*, some resemble *obsoleta*, and some resemble *messana*.

West of Chesapeake Bay and north of the James River, in Virginia, *T.f. fallax* occupies the pine woods and mixed mesic woods of the inner coastal plain. The outer edges of the pleistocene necks are occupied by *T.f. obsoleta*, especially in wet woods and marshes. In trash heaps and along the railroad in the city of Hampton, however, where the two have met quite recently, every grade of intermediacy between the two extremes may be found in a single colony.

In the pine woods near Columbia, South Carolina, where *T.f. fallax* and *T.f. vannostrandi* meet, there are a few homogeneous intermediate colonies. In the town itself, *fallax*, *hopetonensis*, *alabamensis*, and *vannostrandi* have combined in varying degrees on waste ground, giving rise to many populations of "weed snails". The combination *Triodopsis f. fallax* X *Triodopsis f. alabamensis* has appeared in other disturbed areas from southwestern Virginia to central Georgia, and has been given the name *Triodopsis fallax affinis* by Leslie Hubricht (Figure 2: D).

The following hybrid populations have been found



Figure 3. Genitalia of *Triodopsis*.

- A. *Triodopsis fallax obsoleta* (Pilsbry). NMC 59893. Leon, Anne Arundel Co., Maryland. Retracted anterior genitalia, with views of interior of penis (a) and spermathecal duct. Scale = 1 mm.
- B. *Triodopsis fallax fallax* (Say). NMC 63132. Chance, Somerset Co., Maryland. Extended penis. The shells of members of this population indicate slight introgression from *obsoleta*. Scale = 1 mm.
- C. *Triodopsis cragini* Call. TOPOTYPES. Chetopa Co., Kansas. Retracted anterior genitalia and outline of extended penis. Figures redrawn from Webb, 1959, pp. 27 - 28.

in the field: *fallax* X *obsoleta* (synanthropic and natural); *messana* X *obsoleta* (synanthropic); *messana* X *soelneri* (synanthropic, only once); *fallax* X *hopetonensis* (synanthropic); *vannostrandii* X *hopetonensis* (synanthropic); *fallax* X *vannostrandii* (synanthropic and apparently natural); *fallax* X *vannostrandii* X *hopetonensis* (synanthropic); *fallax* X *alabamensis* (synanthropic).

The following taxa have been found living together without intergradation: *messana* and *hopetonensis*; *obsoleta* and *hopetonensis*; *soelneri* and *hopetonensis*; *soelneri* and *messana*. Although *fallax* has not been found with *messana*, a small intermediate population which may be of hybrid origin has been found in southern North Carolina.

I believe that the two major inland populations, *Triodopsis fallax fallax* in the north, and *Triodopsis fallax alabamensis* in the south, give rise to similar populations of dark snails with reduced teeth when they moved onto the unstable coastal plain from the older land of the piedmont, probably in Pleistocene times or earlier (see Hubricht, 1971: 42). Although the coastal plain populations resemble each other by being dark in color and having reduced apertural teeth, all of the populations are distinct, and it is likely that they resulted from different waves of migration onto the coastal plain. From *Triodopsis fallax fallax* two populations with severely reduced dentition resulted: *T. f. obsoleta* on the outer coastal plain between the Delmarva peninsula and north-

eastern South Carolina, and *T. soelneri* in the Bay District between the Cape Fear and Lumber Rivers in southern North Carolina. In the north, *obsoleta* is coming into contact with *fallax*, possibly because rising seas since Wisconsin time are driving it inland. *Soelneri* appears to have been isolated longest. It may have occupied more territory in the past. *Messana* appears to have arisen quite recently. It may have arisen from an early precursor of *soelneri*. Because of the rarity of the *messana* X *soelneri* cross, it is obvious that these two entities have evolved a fairly effective reproductive barrier.

From *Triodopsis fallax alabamensis*, two populations have resulted: *Triodopsis fallax vannostrandii* on the sand barrens and pine savannahs and *Triodopsis fallax hopeotonensis* on the lower coastal plain. In eastern Alabama, *T. f. alabamensis* occupies upland woods and *T. f. vannostrandii* the low ground (Hubricht, pers. comm.). *T. f. hopeotonensis* now has a very wide distribution largely because of its anthropochorous habits. It has evolved to the point where it can co-exist in nature with *T. f. obsoleta*, *T. f. messana*, and *T. soelneri* without hybridization.

Within the subgenus *Triodopsis s.s.*, the following species are too poorly known to assign to a species group, although each taxon appears to be distinct. They require either dissection or attempts to be made to cross them with presumed relatives, or both: *Triodopsis pendula* Hubricht, 1952; *Triodopsis neglecta* (Pilsbry, 1899); *Triodopsis palustris* Hubricht, 1958; *Triodopsis picea* Hubricht, 1958; *Triodopsis rugosa* Brooks and MacMillan, 1940; *Triodopsis fulcidens* Hubricht, 1952; *Triodopsis claibornensis* Lutz, 1950. None of these appear to truly intergrade with other species in the material examined. A report is soon to be prepared on the structure of the genitalia of most of these species.

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THE FALL LINE AS A BARRIER TO THE DISTRIBUTION OF SOME UNIONIDS (BIVALVIA: UNIONIDAE)

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The Coastal Plain Physiographic Province of eastern and southern North America is an area of flat or gently rolling topography and soft or poorly-compacted bedrocks. The coastal and marine sediments which make up the bedrock of this province have been deposited in association with the rise and then gradual fall of the sea level since the beginning of Upper Cretaceous time, about 100 million years ago.

Along the inner edge of the Coastal Plain, the soft Cretaceous sediments interface with older and much harder rocks. Streams which arise in these older physiographic provinces, and flow across the Coastal Plain to the ocean, often include a steep rapids or falls where they flow off the last of the resistant strata and onto the easily eroded Coastal Plain deposits. Along the East Coast this line of falls, or Fall Line, runs from Philadelphia, Pennsylvania, through Richmond, Virginia, Columbia, South Carolina, and Macon, Georgia to Montgomery, Alabama. The Fall Line has been of considerable economic interest because it generally marks the head of river navigation and offers an excellent source of water power to run mills, and more recently, electric generating stations.

Some recent research on the distribution of aquatic organisms may also make the Fall Line the subject of considerable biological and zoogeographic interest. In his study of the fishes of Alabama, Smith-Vaniz (1968) states that the Fall Line clearly delimits the ranges of numerous species. This statement, and the fact that members of the bivalve Family Unionidae are obligate fish parasites during part of their life cycles, leads directly to the conclusion that the Fall Line may serve as a barrier for some unionids as well as for their fish hosts. No previous discussion of this hypothesis has been published, however, both Heard (1970) and Johnson (1970) mention the general paucity of unionid species above the Fall Line.

An examination of the effect of the Fall Line was included in the evaluation of a unionid survey of four creek systems in east-central Alabama (Jenkinson, 1973). This study included Halawakee Creek and the Uchee Creek system of the Chattahoochee River drainage and Saughatchee Creek and the Uphapee Creek system of the Tallapoosa River drainage. The headwaters of these creeks originate near Auburn, Lee County, Alabama. The Fall Line crosses tributaries of both Uchee and Uphapee creeks and essentially divides the study area into northern and southern halves.

Forty-seven of the eighty collection sites yielded 2646 specimens of 27 species of unionids. While none of the 27 species were collected only above the Fall Line, 15 species were collected largely or only below it. Personal collections outside the study area and the site records listed by Clench and Turner (1956), Johnson (1967; 1970) and van der Schalie (1938) demonstrate that ten of the 15 species have been taken above the Fall Line in more than one river system. Recently, site records of the remaining five species in the collection of the Museum of Zoology, Ohio State University (OSUM) were added to the published and personal data. The following annotated list presents the accumulated distributions of these five species with special reference to the Fall Line. The scientific names used in this list are generally those of the current literature; their use here is not necessarily meant to reflect support for these specific names or combinations.

Anodontoideus radiatus (Conrad, 1834)

This Study: Forty-six specimens were collected at eight sites; two of these specimens were taken from one site above the Fall Line.

Other Records: Nineteen sites in the Alabama, Escambia and Apalachicola river systems; one of these sites is above the Fall Line [Chattahoochee River, West Point, Troup Co., Georgia (Clench and Turner, 1956) (Johnson, 1967)].

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Alasmidonta triangulata (Lea, 1858)

This Study: Seventeen specimens were collected at four sites, all below the Fall Line.

Other Records: Fourteen sites in the Apalachicola, Ogeechee, Savannah, and Cooper-Santee river systems; one of these sites is above the Fall Line [Mulberry Creek (of Chattahoochee River) 3 mi S Mountain Hill, Harris Co., Georgia (Clench and Turner, 1956)].

Fusconaia rubida (Lea, 1861)

This Study: Twenty specimens were collected at four sites, all below the Fall Line.

Other Records: Thirty-seven sites in the Amite, Tangipahoa, and Alabama river systems; six sites on the Cahaba River (van der Schalie, 1938) and one site each in the Black Warrior and Coosa river drainages (OSUM) are above the Fall Line.

Pleurobema pyriforme (Lea, 1840)

This Study: Thirty-six specimens were collected at three sites; six of these specimens were taken at one site above the Fall Line.

Other Records: Twenty sites in the Apalachicola, Ocholockonee, and Suwannee river systems, none of which is above the Fall Line.

Lampsilis subangulata (Lea, 1840)

This Study: Forty-three specimens were collected at seven sites, none of which is above the Fall Line.

Other Records: Thirty-four sites in the Choctawhatchee, Apalachicola, and Ocholockonee river systems; two of these sites are above the Fall Line [Flint River 5 mi E Alvaton, Meriwether/Pike Cos., Georgia (OSUM) and Flint River 3 mi SE Gay, Meriwether/Pike Cos., Georgia (personal)].

This rather limited study suggests that these five species of unionids are largely restricted to the Coastal Plain Physiographic Province. Their general lack of penetration above the Fall Line may be caused by substrate, water chemistry, turbidity, fish-host, or some combination of these and/or other requirements, all of which may change drastically as a stream falls onto the Coastal Plain. The lack of penetration of some unionids and fishes may also be the result of the physical barrier of the falls themselves. On Little Uchee Creek, for example, the falls consists

of a solid face of bedrock two to three meters high which extends completely across the stream.

Regardless of the reasons for the general restriction of these five species to the Coastal Plain, this study suggests that the distributions of some unionids are limited by the Fall Line or by factors related to this feature. If this suggestion is supported by additional site records for these and other Coastal Plain species, some of our present concepts of migration patterns, affinities among species, and other zoogeographic relationships may have to be modified. We may also realize, and be able to document, that some Coastal Plain species are in greater danger of extinction than we had previously believed. Whatever the outcome of these additional studies, we will certainly add to our meager knowledge of the unionids of the Coastal Plain.

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VARIATIONS IN THE INCURRENT AND EXCURRENT APERTURES OF *QUADRULA QUADRULA* RAFINESQUE, 1820 AND *QUADRULA PUSTULOSA* (LEA, 1831)¹

Frank L. Kokai*

Early students of North American naiads recognized soft parts as an aid to identification and classification. Rafinesque (1820) was the first to illustrate soft parts and Barnes (1823) stated that "perfect accuracy" in distinction between species depends upon examination of soft parts. Agassiz (1851) reported that identification should be based on shell characters and soft parts and listed the structures he felt were significant to taxonomy. Isaac Lea (1859) discussed the value of observing soft parts and specifically illustrated naiad apertures and papillae. George B. Simpson (1884) was among the first to write an extensive paper on naiad soft parts with detailed illustrations. Charles T. Simpson (1900) organized the naiads on the basis of soft parts wherever possible.

While these experts, and others, recognized variation in shell characters, little was written about variation of the soft parts. Descriptions of soft parts dealt mainly with the gills, and terms such as "large", "numerous", "normal", etc. are found applying to other structures (Baker, 1898, Ortmann, 1912). In some cases color is the only description (Ortmann, 1911, 1912). Very little recent quantitative work has been done to determine how much variation occurs in the soft parts and how variation may affect taxonomy. The objective of this study was to measure and compare soft parts to determine variability and perhaps find potential taxonomic characters.

Specimens used for this study were collected by skin diving and SCUBA diving in Fishery Bay of western Lake Erie between Gibraltar Island and South Bass Island, Ottawa County, Ohio. Twenty-eight collections were made during the summer of 1970 which yielded 833 specimens representing 3 subfamilies, 15 genera, and 18 species of the family Unionidae. Twenty-eight *Quadrula pustulosa* (Lea, 1831) and twenty-five *Quadrula quadrula* Rafinesque, 1820 were among those specimens collected and this material became the basis of this study.

Specimens were returned to the laboratory where the shells were pegged open with small cork stoppers.

The specimens were then fixed in a solution of 75% ethanol, 20% water, and 5% glycerine. After fixing, the soft parts were dissected from the shells and stored separately. Shells and soft parts were processed into the collections of the Ohio State University Museum of Zoology where they are now preserved.

A data sheet was prepared for each specimen to note the following: species, catalog number, collection number, length of incurrent, excurrent, and accessory apertures, type and number of aperture papillae, structures of the mantle such as flaps, papillae, and ridges, marsupium length, shape, and development, length of the animal, and additional comments such as parasite infestations etc. This paper represents only a portion of the entire study. Lengths of the three apertures and the entire animal were measured using a needlepoint divider and a metric rule. All measurements were taken to the closest millimeter. Papillae were observed and counted using a binocular microscope at a magnification between 16x and 24x.

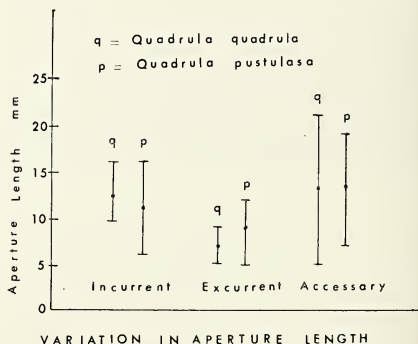


Fig. 1. Absolute Variation in Aperture Length.

1 *Q. pustulosa* (Lea, 1831) = *Q. bullata* Rafinesque, 1820 according to Dr. J.P.E. Morrison (pers. comm.) but in the interest of clarity the more familiar name *Q. pustulosa* is used here.

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Absolute measurements of the three apertures of *Q. quadrula* and *Q. pustulosa* (figure 1) indicate the excurrent aperture is the smallest and least variable of the three in both species. *Quadrula pustulosa* has a greater variability in excurrent aperture length and a larger mean, 9 mm compared to 7 mm. The incurrent aperture was slightly larger in both species with a mean of 12 mm in *Q. quadrula* and 11 mm in *Q. pustulosa*. *Quadrula pustulosa* was again more variable. The accessory aperture is the largest and most variable with a mean of 13 mm for both species. Because the absolute measurements are dependent on animal size, greater aperture variability in one species could be explained by a greater range of animal size. Although *Q. pustulosa* was more variable in animal size and incurrent and excurrent apertures, *Q. quadrula* was more variable in absolute accessory aperture length.

To compare relative lengths of apertures of animals of different sizes, a length index was calculated by dividing animal length into aperture length. This percentage was then multiplied by 1000 to give a whole number (figure 2). The use of this index reveals that an "average" *Q. quadrula* has an incurrent aperture with an index of 100, an accessory aperture of 160, and an excurrent of 170. The accessory aperture is the most variable. Several specimens have very large (25% animal length) or small (7% animal length) accessory apertures but most were about 15% animal length, roughly the same size as the incurrent aperture.

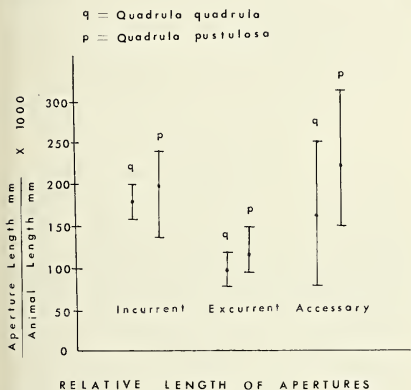


Fig. 2. Relative Length of Apertures.

The "average" *Q. pustulosa* has relatively larger apertures with indices of 120 for the excurrent, 200 for the incurrent, and 220 for the accessory. Both species have approximately the same degree of relative variability for the excurrent and accessory apertures, but *Q. pustulosa* has a more variable incurrent aperture.

The most obvious structures of the apertures are the incurrent aperture papillae. Both species have complex and variable arrangements and number of

papillae. Many of the species taken from Lake Erie have as few as 25 solitary papillae along each margin of the aperture. The papillae of *Q. quadrula* and *Q. pustulosa* are more numerous and are arranged in "clusters" which border the aperture margin.

In *Q. quadrula* the clusters are brown at the base and white at the tips giving a gross appearance of brown. As the animal gets older, the papillae darken until reaching a brown-black color. The number of clusters varies between 8-14 per side, but one side of the animal may have more clusters than the other. The number of individual papillae per cluster varies between 4-23. These papillae may bifurcate several times (figure 3). The number of papillae tips ranges from 90 to 140 per aperture side. Between the clusters are solitary papillae which may bifurcate. The presence of these papillae between clusters appears to be at random but they are always found at the dorsal and ventral margin of the aperture.

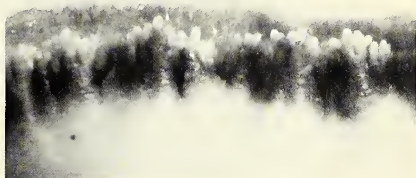


Fig. 3. The papillae of *Quadrula quadrula* Rafinesque, 1820 located in the inner margin of the right incurrent aperture (x20). Characteristics of the papillae are bifurcations from clusters, brown base, and white tips.

In *Q. pustulosa* the papillae are also arranged in clusters but three general differences occur: 1) the color of the papillae is somewhat lighter, although this is hard to observe without the aid of a microscope, 2) there are less solitary papillae between the clusters, and those which do exist rarely bifurcate, 3) the papillae of the clusters rarely bifurcate. The number of clusters per aperture side is 12-28 and the number of papillae per cluster is 10-19. Total number of papillae is between 120-160 per side.

For these two species of this population the use of aperture size ratios is not justifiable as a taxonomic character. The relative size ratios of the incurrent, excurrent, and accessory apertures are 10:17:16 in *Q. quadrula* and 12:20:22 in *Q. pustulosa*. The high degree of variability, particularly the accessory apertures, makes these ratios meaningless. No specimen exhibited these ratios exactly and most specimens were not close to the mean in more than one relative aperture size.

Ortmann (1911) states that papillae of the branchial (incurrent) opening "although slightly varying in their development (offer) no remarkable differentiations." I cannot agree with this statement. The 18 lake species observed do have distinct

papillae. For the two species in this study, correct identification could be made on the basis of papillae with approximately 80% accuracy. Further studies should be made to determine what differences occur between lake and stream forms, other species of the genus, and other genera. Further study could disclose a helpful taxonomic aid.

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PHILOBRYIDAE IN THE NORTHERN HEMISPHERE

Donald R. Moore*

The Philobryidae are a group of poorly known bivalves living mainly in the southern hemisphere. They are poorly known because most species measure two or three millimeters, and little is known of them beyond the original description. The family was unknown in the tropical western Atlantic until comparatively recently.

David Nicol (1970), when discussing living Antarctic bivalves stated that only one species of Philobryidae *Philobrya setosa* (Carpenter, 1864), eastern Pacific, was now living in the northern hemisphere. Unfortunately, Nicol had overlooked the description of two small philobryids described from the Caribbean in 1958. *Philobrya inconspicua* Olsson and McGinty, 1958, and *Cosa caribaea* Abbott, 1958, are very small bivalves, and are considered quite rare. Both have been reported only from the type locality, Bocas del Toro for *P. inconspicua*, and Grand Cayman for *C. caribaea*.

Shortly after reading Nicol's article, I collected bottom samples from depths of 12 m and 14 m near Buck Island, St. Croix, U.S. Virgin Islands. *Cosa caribaea* was found to be a common species at this depth, but was not present in samples from lesser depths behind the reef. Thus the supposed rarity of this species is apparently simply an artifact of collecting. The small size of the species (1.5 mm) also contributes to our lack of knowledge of this bivalve.

I also examined a bottom sample from Arrowsmith Bank, a small flat topped rise a few km east of northeastern Yucatan, and found a third Caribbean species (description in manuscript). This material came from a depth of 37 to 405 m trawled up a steep slope, and was found in CaCO₃ sand which presumably had been carried down slope from the flat top. The original depth must have been some 25 to 35 m. This material was collected by the University of Miami R/V Gerda on a cruise to Arrowsmith Bank

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in 1967.

This, then, makes a total of four philobryids living north of the Equator. However, Abbott, 1958, suggested that *Limopsis antillensis* Dall, 1881, also belonged in the Philobryidae. At first glance, this seems a poor idea as the prodissoconch is not a large cap-like structure typical of many philobryids. A close examination, though, does show a number of characters that *L. antillensis* has in common with the two Caribbean species of *Cosa*. They are: straight hinge line, small, triangular ligament, low cancellate sculpture, two or three internal ribs which become prominent on the posterior margin, many fine tubules which run through the shell at right angles, and a large posterior adductor muscle scar, obsolete anterior scar. In addition, the hinge of *L. antillensis* is like that of *Cratis* with two or three teeth on each side of the ligament.

A similar species, described from the Upper Miocene of Matanzas, Cuba, is *Limopsis pentodon* Aguayo and Borro, 1946. This little clam, known only from the original description, has been found in recent sediments collected off the coast of Belize by Dr. Donald Marszalek, and from the north coast of Jamaica by Dr. Peter Supko and John F. Meeder.

Both *L. antillensis* and *L. pentodon* appear to belong to the genus *Cratis* Hedley, 1915. They are both small, ranging in size from about 2.5 to 4.0 mm. *Cratis antillensis* is found in the Upper Gulf of Mexico, and so is the only known philobryid living on the Atlantic continental shelf of the United States. *Cratis*, until now, has only been known from the south Pacific: these new records greatly extend the range of the genus.

So now, instead of one species living in the northern hemisphere, there are six. They are as follows:

- Philobrya setosa* Carpenter (eastern Pacific)
- P. inconspicua* Olsson and McGinty
- Cosa caribaea* Abbott
- Cosa* sp. (Arrowsmith Bank)
- Cratis antillensis* Dall
- C. pentodon* Aguayo and Borro

The number for the tropical western Atlantic is also six, for Klappenbach, 1966, described *Cosa brasiliensis* from the southern coast of Brazil.

Finding additional species of philobryids in the

Northern Hemisphere is of interest to zoogeographers, paleontologists, and bivalve specialists. What is far more interesting is the implication that Australian and Caribbean mollusc faunas are more closely related than is usually thought. This relationship is concealed by a welter of generic and subgeneric names, or by the placing of closely related groups in different families or even orders. Hence an *Orbitesella* in the Caribbean is placed in *Cyclostremiscus*, while *Amphithalamus* in Australian waters is put into *Scrobs*. There are many genera and some families which are found in only one of the two areas, but much more effort has gone into pointing out differences than in showing affinities.

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MARYLAND AND VIRGINIA MUSSELS OF LISTER

Joseph P.E. Morrison*

Freshwater Mussels from the colonies figured as "*Mya*", "*Mytilus*", and "*Pectunculus*" by Lister in 1686 included members of each subfamily living today in the Chesapeake Bay Region. Most of them, such as *Elliptio complanatus* Lightfoot, and *Lampsilis radiata* Gmelin, have been universally recognized since they were scientifically named. In contrast, two species of the James River of Virginia are not commonly known by their earliest names. Of the Unionidae, subfamily Anodontinae, the "Red Anodonta" is correctly known as *Anodonta* (*Pyganodon*) *fucata* Dillwyn, 1817, while the plate 157, figure 12 "*Pectunculus*", of the Amblemidae, subfamily Lampsilinae, is only correctly known as *Leptodea fluviatilis* Gmelin, 1791. The various mistaken listings of these names, *fucata*, and *fluviatilis*, or their omissions, are indicated in the following synonymies of the past century and a half.

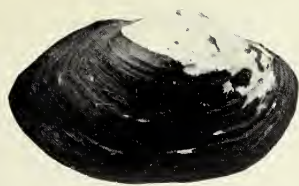
ANODONTA (PYGANODON) FUCATA (Dillwyn, 1817)

Figs. 5-8

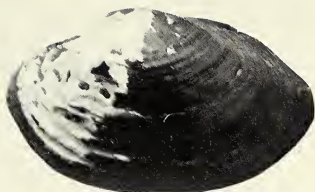
- 1686 --- Lister, Hist. Conch., pl. 154, fig. 9. (Va.)
- 1770 --- Lister (Huddesford), Hist. Conch., pl. 154, fig. 9 (Va.)
- 1786 *Mytilus fucatus* Solander Mss, Lightfoot, Portland Cat., p. 29, lot 672. (Md.) NUDE NAME.
- 1817 *Mytilus fucatus* Dillwyn, Descr. Cat., p. 317. (minus the European *avonensis* synonymy).
- 1823 *Mytilus fucatus* Dillwyn, Index to Lister, p. 13.
- 1829 *Anodonta implicata* Say, N. Harmony Diss., 2, no. 22, p. 340.
- 1834 *Anodonta implicata* Conrad, New Freshwater Shells, p. 73.
- 1835 *Anodonta implicata* Férussac, Guérin's Mag., p. 250.
- 1838 *Anodonta newtonensis* Lea, Trans. Am. Phil. Soc., 6: 79, pl. 21, fig. 66.
- 1838 *Anodonta newtonensis* Lea, Observations, 2: 79, pl. 21, fig. 66.
- 1838 *Margarita* (*Anodonta*) *implicata* Lea, Synopsis, p. 30.
- 1838 *Margarita* (*Anodonta*) *newtonensis* Lea, Synopsis, p. 30.

- 1840 *Anodonta implicata* Say, New Land and Freshwater Shells, p. 10.
- 1840 *Anodonta implicata* L.W. Say, Terr. & Fluv. Shells, p. 11.
- 1841 *Anodon implicata* Gould, Invertebrata Mass., p. 118, fig. 78.
- 1843 *Anodon implicata* DeKay, Nat. Hist., N.Y., Moll., p. 202.
- 1843 *Anodon excurvata* DeKay, Nat. Hist., N.Y., Moll., p. 202, pl. 17, fig. 233.
- 1845 *Anodonta housatonica* Linsley, Am. Journ., Sci., Ser. I, 48: 277. NUDE NAME.
- 1845 *Anodon newtoniana* Catlow & Reeve, Conch. Nomencl., p. 67.
- 1848 *Anodonta housatonica* Gould, Am. Journ. Sci., Ser. II, 6: 234, figs 4-5.
- 1851 *Anodonta implicata* Stimpson, Shells of New England, p. 15.
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- 1852 *Margaron* (*Anodonta*) *implicata* Lea, Synopsis, p. 50.
- 1853 *Anodonta implicata* Conrad, Proc. A.N.S.P., 6: 264.
- 1853 *Anodonta excurvata* Conrad, Proc. A.N.S.P., 6: 264.
- 1856 *Anodonta implicata* Girard, Proc. Nat'l. Inst. Wash., D.C., N. Series, vol. 1, no. 2, p. 79.
- 1862 *Anodonta williamsii* Lea, Proc. A.N.S.P., 6: 169.
- 1862 *Anodonta williamsii* Lea, Observations, 11: 31, pl. 10, fig. 26.
- 1867 *Anodon newtonensis* Sowerby, Conch. Icon., 17, pl. 17, fig. 62.
- 1870 *Anodon implicata* Binney's Gould, Invertebrata Mass., p. 180, fig. 481.
- 1870 *Margaron* (*Anodonta*) *implicata* Lea, Synopsis, p. 80.
- 1870 *Margaron* (*Anodonta*) *williamsii* Lea, Synopsis, p. 81.
- 1873 *Anodonta implicata* Clessin, Conch. Cab. *Anodonta*, p. 78, pl. 19, fig. 3.

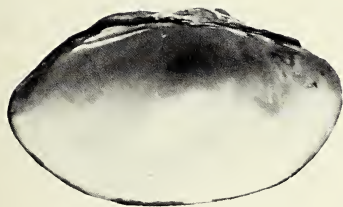
* Division of Mollusks, U.S. National Museum (Natural History), Smithsonian Inst., Washington, DC 20560



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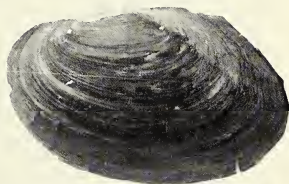
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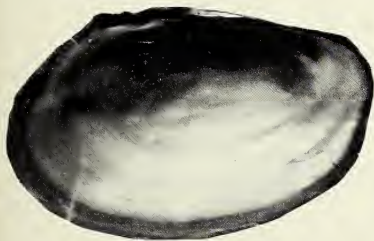
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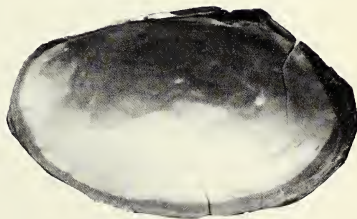
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Figs. 1-4: *Mytilus fluviatilis* Gmelin. Neotype. USNM 709986

Figs. 5-8: *Mytilus fucatus* Dillwyn. Neotype. USNM 709985

- 1874 *Anodon implicata* Hartman & Michener, Conch. Cestrica, p. 94, fig. 193.
- 1890 *Anodonta implicata* Carpenter, Nautilus, 4: 57.
- 1900 *Mytilus fucatus* Simpson, Proc. U.S.N.M., vol. 22, p. 622. (incorrectly synonymous under *cygnaea* of Europe).
- 1900 *Anodonta implicata* Simpson, Proc. U.S.N.M., vol. 22, p. 633.
- 1914 *Mytilus fucatus* Simpson, Descript. Cat., p. 362 (not *avonensis* Mont., incorrectly synonymous under *cygnaea* of Europe).
- 1914 *Anodonta implicata* Simpson, Descript. Cat., p. 391.
- 1919 *Anodonta implicata* Ortmann, Mem. Carnegie Mus., 8: 159, pl. 11, fig. 2,3.
- 1927 *Anodonta implicata* Frierson, Checklist, p. 16.
- 1946 *Anodonta implicata* Johnson, Occ. Pap. Moll., 1: 112, pl. 16, fig. 1,2.
- 1959 *Anodonta implicata* Clarke & Berg, Cornell Univ. Exp. Sta. Mem. no. 367, p. 40, fig. 42.
- 1962 *Anodonta implicata* Athearn & Clarke, Nat'l Mus. Canada, Bull. 183, p. 26, pl. 2, figs. 1-2.
- 1969 *Anodonta (Pyganodon) implicata* Haas, Tierreich 88, Unionacea, p. 368.
- 1970 *Anodonta (Pyganodon) implicata* Johnson, Bull. M.C.Z., vol. 140, no. 6, p. 360, pl. 15, fig. 4; pl. 16, figs. 1-2.
- 1973 *Anodonta implicata* Johnson & Baker, Proc. A.N.S.P., 125 (no. 9), p. 158.
- The name given by Dillwyn in 1817 is distinctive; *fucata* means painted, or painted red, in Latin. This agrees with the very brief Latin description of Lister — *Musculus angustior, subfuscus, paulo crassior*, — for this species of *Anodonta*, which is elongate in typical adult shells. The pale copper or salmon color of the nacre is normally specific, as Johnson has noted in 1970. Also characteristic is the habitat in sand or gravel bottoms, in contrast to that of most other *Anodonta* species, in muddier or silty sands. This species, *fucata* of Dillwyn, is apparently not, and has not been living south of the Chesapeake Bay Drainage, since Lister figured it. The pale colored form from the Potomac River south of Mount Vernon named *williamsii* by Lea may now be extinct because of pollution. It is interesting to note the re-discovery of this species in Virginia, almost 300 years after the original Listerine locality was published.
- The first specimen of this *Anodonta* I ever personally collected was found in shallow water in current-swept gravel, in the lower Appomattax River, of the James River System, near Hopewell, Virginia, June 12, 1973. This specimen, from near the original locality of Lister, U.S.N.M. No. 709985, is hereby declared the NEOTYPE of the species *Anodonta (Pyganodon) fucata* Dillwyn, 1817.
- LEPTODEA FLUVIATILIS (Gmelin, 1791)
Figs. 1-4
- 1686 *Pectunculus* — Lister, Hist. Conch., Pl. 157, fig. 12.
- 1770 *Pectunculus* — Lister (Huddesford Edn.), pl. 157, fig. 12.
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- 1801 *Anodonta fluviatilis* Bosc, Hist. Nat. de Coquilles, vol. 3, p. 146.
- 1816 *Anodontes fluviatilis* Cuvier, La Regn. Animal, vol. 2, p. 472.
- 1817 *Mytilus fluviatilis* Dillwyn, Descr. Cat., p. 316.
- 1817 *Unio ochraceus* Say, Nicholson's Encyclopedia, p. 2, pl. 3, fig. 8.
- 1820 *Lampsilis rosea* Rafinesque, Ann. Gen. de Sci. Phys. Bruxelles, vol. 5, p. 299; separate, p. 33.
- 1820 *Unio (Metaptera) ochracea* Raf., Ann. Gen. de Sci. Phys. Bruxelles, vol. 5, p. 300. separate, p. 34.
- 1823 *Mytilus fluviatilis* Dillwyn, Index to Lister, Hist. Conch., p. 13.
- 1824 *Anodonta fluviatilis* Bosc, Hist. Nat. de Coq. (2nd Edn.), vol. 3, p. 143.
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- 1832 *Lampsilis rosea* Raf., (Poulson Translation), p. 28.
- 1832 *Unio (Metaptera) ochracea* Raf. (Poulson Translation), p. 29.
- 1834 *Unio ochraceus* Conrad, New Freshwater Shells, p. 70.
- 1834 *Symphynota ochracea* Lea, Observations, I, p. 69.
- 1835 *Unio ochraceus* Férussac, Guerin's Magazine, p. 25.
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- 1842 *Unio ochraceus* Hanley, Test. Moll., p. 190.
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- 1864 *Unio (Metaptera) ochracea* Raf., Binney & Tryon — Reprint, p. 45.
- 1868 *Unio ochraceus* Sowerby, Conch. Icon., 16, pl. 63, fig. 317.
- 1870 *Unio ochraceus* Binney's Gould, Invertebrata Mass., p. 173, fig. 476.
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- 1895 *Unio ochraceus* Simpson, Nautilus, vol. 8, p. 122, figd.
- 1900 *Lampsilis ochraceus* Simpson, Bull. U.S.N.M., vol. 22, p. 530.
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- 1919 *Lampsilis ochracea* Ortmann, Mem. Carnegie Mus., vol. 8, p. 318, pl. 20, figs. 6-7.
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- 1959 *Lampsilis ochracea* Clarke & Berg, Cornell Univ. Exp. Sta., Mem. no. 367, p. 57, figs. 55-56.
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- 1969 *Lampsilis (Lampsilis) ochracea* Haas, Tierreich, Unionacea, p. 454.
- 1970 *Lampsilis ochracea* Johnson, Bull. M.C.Z., vol. 140, no. 6, pp. 388-390, pl. 21, figs. 14-15.
- 1973 *Unio ochraceus* Johnson & Baker, Proc. A.N.S.P., vol. 125, no. 9, p. 163.

A search of all pertinent literature shows that Conrad in 1836 correctly named this species. His account of *Unio ochracea*, var. *fluvialtilis* Gmelin, from Virginia, tells the whole story. Lister figured this shell as *Pectunculus*, thereby declaring it had (sub-equal) teeth on the hinge, both anterior and posterior to the beaks or umbones. Conrad said: "variety A (*fluvialtilis*) is very abundant in James River, Virginia, where I found vast numbers of shells brought ashore by seines used in the shad fishery in March. So accurately does the above mentioned variety agree with Lister's figure and description, that I cannot doubt the identity The specimen

figured has a double cardinal tooth in each valve." Such double cardinal teeth in each valve coincides with Lister's original placement of the shell as *Pectunculus*. Conrad's reference to the shad fishery specimens seized from the James River probably indicates the original method and place of discovery of this species, almost, if not exactly, three hundred years ago.

The references by Isaac Lea and others, of *fluvialtilis* of Dillwyn to *Anodonta cataracta* Say, 1817, are false. There is no *Anodonta* species from Colonial Virginia that has high enough, swollen umbones to match Lister's figure 12. Apparently Gmelin called it *Mytilus fluvialtilis* because he saw no hinge teeth in the (external only) figure. He forgot to read Lister's *Pectunculus*; we agree with Conrad's correction of this mistake by Gmelin.

Conrad's 1836 reference to the earliest name *fluvialtilis* Gmelin, 1791 was completely and/or deliberately ignored by Isaac Lea, who left all fully dentate mussels in the genus *Unio* all his life. On the other hand, Lea in 1872, page 77, footnote, was not too sure about the name for Lister's plate 157; he said: "probably *Unio cariosus* Say." In the past century, it was "*Unio*" for all references except Rafinesque 1820, et seq., Stimpson 1851, and then Simpson in 1900, who apparently put *ochracea* under *Lampsilis* on account of the sexual dimorphism of the shells. All previous authors in this century have left the species in *Lampsilis*, simply because they did not study the anatomy critically or comparatively.

Personal research on this species, mostly since 1971, has proven two things. Firstly — *ochracea* of Say is the same as *fluvialtilis* of Gmelin. Secondly — it does not belong to the genus *Lampsilis*. Both Isaac Lea in 1838, and Reardon in 1929, figured the gross anatomy of this Atlantic species. Recent examinations of numerous females from the Tar River, and from Lake Waccamaw, North Carolina, have corroborated the figures of Lea and Reardon. With smaller glochidia, and a complete lack of "mantle flaps" or papillae on the mantle margins of females, ventral to the siphonal area, it is clearly a species of *Leptodea*. This genus, of the subfamily Lampsiliinae, has not previously been recognized as including any species living in the Atlantic Slope rivers.

No one has yet determined the fish host or hosts of this mussel, but I believe it will be found to be one of the anadromous species of Herring, Alewife, or Shad, of the genus *Alosa*. *Leptodea fluvialtilis* has not been carried by its fish hosts above the Fall Line, in rivers wherever there is a distinct falls, as at the Great Falls of the Potomac. I have not seen any specimens of this species, or of *Lampsilis cariosa* Say, that were found living upstream of the Great Falls of the Potomac.

The specimen figured was taken with a mussel bar in 18 feet of water in the lower Appomattox River, of the James River System, near Hopewell, Virginia, June 12, 1973. Because of its almost complete accordance with Lister's figure 12 of *Pectunculus*, this specimen, *Leptodea fluvialtilis* U.S.N.M. No. 709986, is here selected as the NEOTYPE of *Mytilus fluvialtilis* Gmelin, 1791.

THE HISTORICAL LIBRARY OF MALACOLOGY AT THE DELAWARE MUSEUM OF NATURAL HISTORY

John Dyas Parker*

With the great burst of exploration triggered by Prince Henry the Navigator of Portugal, about 1450, one country after another sent out exploring expeditions. This enthusiasm has continued until the present time. The first expeditions returned with souvenirs for those who had advanced the money, and many of these souvenirs were exotic shells. Soon the wealthy or politically powerful had curio cabinets of this material and eventually a brisk trade in shells resulted. From this beginning shell collections sprang up all over Europe, reaching a peak between 1650 and 1800.

S. Peter Dance, of the British Museum (Natural History), has gathered information on these collections in a fascinating book called *Shell Collecting, an Illustrated History*. While this book is a wonderful help to the student of European collections and collectors, it doesn't have much to say about North American collections. Not until 1973 when Dr. R. Tucker Abbott and a group of associates compiled *American Malacologists* had much been done about malacological history of this continent. Last November I suggested to Dr. Abbott that material be collected in an archive to be established at the Delaware Museum of Natural History. The American Malacolo-

gical Union maintains such a library at the DMNH, but we decided if we were to put funds into our endeavor, our collection should be the property of the museum and remain there permanently. We then notified the AMU that it could duplicate anything we had in our historical library.

Dr. R. Tucker Abbott and I put up most of the funds to meet the costs involved while the DMNH underwrote the housekeeping expenses. Using *American Malacologists* as a base, I started in January to write over 670 persons listed in the book. From these I have received many obituaries, biographies, vitas, much correspondence and nearly 1000 pictures of collectors. My wife, a graduate librarian, and I set up dossiers on each person listed in AM and established a 14 division color code so we could see at a glance what was available on each collector. Among the illustrations on hand for future historians are photographs of such well-known malacologists as H.A. Pilsbry, C.M. Cooke, L. Hertlein, G.D. Hanna, A.A. Olsson, W.J. Eyerdam, and E.P. Chace. These are but a few of the hundreds of items now in this unique historical library at the Delaware Museum of Natural History. Further contributions are welcome.

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REMARKS ON WESTERN ATLANTIC *ANACHIS*

Dorothy Raeihle*

The identification of several species of *Anachis* is difficult because of the variability in color and dimension of shells within a species or among specimens from the same station. In addition, the appearance of the living animals is so alike that one description is applicable not only to several species of *Anachis* but also to species of *Mitrella* and *Nitidella*. Of *Anachis* personally observed in aquaria, one still unidentified species, collected in the Florida Keys, deposited cap-

sules each containing a single egg to hatch as crawling young (Raeihle 1969; cf. ANSP 219895, 334590). Each of the other species so observed, and those in Brazil observed by Marcus and Marcus (1962), hatched as swimming veligers.

Anachis iontha (Ravenel, 1861) collected at Sanibel, Florida, varied greatly in color. It was identified by comparison of its egg capsules with those figured for *Pyrene albella iontha* (Ravenel, 1861) by

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Perry and Schwengel (1955, Pl. 50, fig. 344) and later with shells in the collection of ANSP. *A. floridana* Rehder, 1939 from Sebastian Inlet, Florida; *A. translirata* (Ravenel, 1861) from Long Island, New York, and *A. avara* (Say, 1822) from Jekyll Island, Georgia and Lake Worth, Florida also bred in the aquaria, each species depositing a capsule of distinctly different sculpture. The identifications of these species were resolved when their egg capsules were figured by Scheltema (1968). It was most interesting that Marcus and Marcus reported egg capsules with structures identical to the above three species for *Anachis* collected near Ubatuba, Brazil, respectively *A. brasiliana* (v. Martens, 1897) and *A. veleda* (Duclos, 1846) both of which deposited egg capsules in captivity. The third type of egg capsule was field-collected; Marcus and Marcus attributed them to *A. sparsa* (Reeve, 1859) on the basis of comparison of the shells of the hatching veligers to the protoconch of adult *A. sparsa*. However, as these capsules are structured as those of *A. avara* (Say) — like little volcanoes, $2 \pm \text{mm}$ — it indicates the desirability of live observation of *A. avara* (C.B. Adams, 1845) (= *A. moleculina* Duclos, 1835) whose range includes the area where the capsules were collected.

Through the courtesy of Dr. J.J. Parodiz, Dr. E.C. Rios, and Mr. Omar E. Sicardi, shells of South American *Anachis* species were received for comparison with North American specimens. The shells of *A. floridana* and *A. brasiliana*, both to around 11 mm, are so alike that small differences of color flecks, and the lack of ribs on postnuclear whorls of *A. brasiliana*, could be attributed to ecological conditions. Their egg capsules are of the same structure: $1 \pm \text{mm}$, moderately globose with a flaring, starlike collar around the hatch area. The shells of *A. translirata* and *A. veleda* are both about 16 mm and have the same general dimensions. They show strong similarities but the many ribs of *A. veleda* are heavy and somewhat keeled at the sutures in comparison with the fine ribs and low shoulders of *A. translirata*. Their egg capsules are of like structure: $1\frac{1}{2} - 2 \text{ mm}$, resembling tiny crushed turbans.

As the shells of *Anachis avara* (Say) and *A. sparsa* (Reeve) were observed to be quite unlike, the shells of *A. avara* (Say) and *A. avara* (C.B. Adams) (= *A. moleculina* Duclos) were compared and found to be close in size ($14 \pm \text{mm}$), dimension and pattern of dentition, but the northern specimens were more strongly ribbed, more colorful, and with more rounded denticles. To add to the confusion, some specimens of *A. avara* (Adams) (= *A. moleculina*) in appearance suggested a large form of *A. brasiliana*. If the reproduction of *A. sparsa* as well as *A. avara* (Adams) (= *A. moleculina*) can be observed in captivity, (hopefully) their egg capsules may resolve the questions of relationship.

Anachis obesa (C.B. Adams, 1845) was also collected at Sanibel, Florida, but did not thrive in our aquarium and so feeding and reproduction was not observed. These shells compare closely with one lot of "*A. isabellei* (D'Orbigny, 1841)" from Uruguay. This is in accord with the report of Parodiz (1962) who gives the southern limit of *A. obesa* as Rio Negro, Patagonia. Other lots of *Anachis isabellei* from Brazil and Uruguay also give substantiation to the opinion of Parodiz, who discussed differences between *A. obesa* and *A. isabellei* and their confusing synonymies, and to the opinions of Sicardi (1967; also personal communication, 1974) and Figueiras and Sicardi (1972) who consider that two species have been lumped under *A. isabellei*. Again, live observation may be of value. Unfortunately, living specimens of *Anachis* are very difficult to obtain along the coast of South America because of generally unfavorable collecting conditions.

In researching the species named in these remarks an interesting pattern of distribution appeared. The northern and southern species compared occurred in similar degrees of north and south latitude; the ranges of all the *Anachis* discussed were generally within latitudes from approximately 10° to 40° north or south.

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MOLLUSKS OF GATUN LOCKS, PANAMA CANAL¹

Joseph Rosewater*

The East chambers of Gatun Locks were dewatered early in March 1974 for repairs. On March 3, 4, and 5 collections were made from floors and walls of the drained upper, middle and lower chambers respectively. Mollusks were collected at six main stations corresponding to the upper and lower portions of each chamber. As the Gatun Locks carry ship traffic from the freshwater Gatun Lake down 85 feet to the level of the Atlantic Ocean this survey was thought to be a good test of the preventive effect of the freshwater barrier of the lake on transport of marine species through the canal.

Hildebrand (1939) reported only two mollusk species from Gatun Locks: *Brachidontes exustus* (Linné) and *Neritina meleagris* Lamarck [= *N. usnea* (Röding)] both also mentioned in the present report; but he made no definite mention of the several additional species found in the present survey. It is not known whether these additional species were present at that time and not collected or if they are new introductions. The locks are dewatered on a more or less regular basis as repairs or cleaning are necessary. Depending on the length of time the chambers are dry, it is probable that many living aquatic inhabitants are killed and must be recruited anew when the chambers are refilled.

As mentioned by Jones and Dawson (1973) a number of attempts have been made to theorize on the possibilities for passage of marine animals through the locks and the conditions which would permit such passage. Jones and Dawson made the first careful temperature and salinity measurements in the several locks of the canal. In the case of the Gatun Locks their readings show that the upper chamber nearest Gatun Lake is virtually fresh water; the middle has a salinity of only a few parts per thousand; the lowest chamber is considerably more saline with readings ranging from 6.3‰ in the upper part to 14.3‰ at its lower end. These salinities apparently are high enough to support life in the marine species found. The upper and middle chambers are inhabited by species with tolerances ranging from freshwater (*Neritina* and *Mytilopsis*) to brackish water. See Table 1.

OBSERVATIONS ON DEWATERED EAST CHAMBERS

Upper chamber — the walls and floor were uniformly fairly bare. *Neritina* predominated in the upper portion with *Mytilopsis* appearing in the lower part; dead shells of *Isoegnomon* and *Brachidontes* were present and are believed to have been washed in from the middle chamber.

Middle chamber — *Neritina* was still present but *Mytilopsis* was becoming more numerous; a few *Brachidontes* were present in the upper part, they were very common at mid point and many were present in the lower part. A few living *Isoegnomon* lay unattached on the floor of the lower part showing evidence of having been washed in from the lowest chamber.

Lower chamber — *Neritina* was absent; living *Isoegnomon* were attached to the walls and floor in large numbers throughout the lock, but were increasingly numerous toward the lower part. *Brachidontes* noticeably clustered around the sump holes in the floor. *Thais* was present at least from the mid to lower end, where the walls were heavily encrusted with organisms: *Arca*, *Chama*, sponge, and tube worms. A single specimen of *Alexania* was collected with its egg mass from the underside of a rock on the floor near the middle of the chamber.

CONCLUSION

The assemblages of mollusks collected in the several chambers of Gatun Locks give considerable support to the statement of Jones and Dawson (1973) that the Panama Canal constitutes a barrier to the migration of the stenohaline marine biota between the Atlantic and Pacific Oceans.

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1 This study is a portion of the National Museum of Natural History — Smithsonian Tropical Research Institute Panama Survey in progress since 1971 to provide adequate collections of and research on that fauna in the event a sea level canal is to be constructed.

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Table 1

Dominant Living Mollusks found in East Chambers, Gatun Locks, March 1974.

Species	Upper Chamber			Middle Chamber		Lowest Chamber	
	1/ U(0.1)	2/ L(0.3)	3/ L(0.3)	U(1.1)	L(1.3)	U(6.3)	L(14.3)
<i>Neritina usnea</i> (Roding)	X	X		X	X		
<i>Mytilopsis sallei</i> (Recluz)		X		X	X		
<i>Brachidontes exustus</i> (Linne)				X	X	X ^{4/}	X
<i>Isognomon alatus</i> (Gmelin)					X	X	X
<i>Alexania floridana</i> (Pilsbry)						X	
<i>Thais haemastoma floridana</i> (Conrad)						X	X
<i>Arca zebra</i> Swainson							X
<i>Arca imbricata</i> Bruguiere							X
<i>Chama macerophylla</i> Gmelin							X
<i>Sphenia antillensis</i> Dall and Simpson							X

1/ U = Upper to middle portion of lock chamber

2/ figures in parentheses are salinities in parts per thousand read at chamber bottoms in April 1972 (Jones and Dawson, 1973)

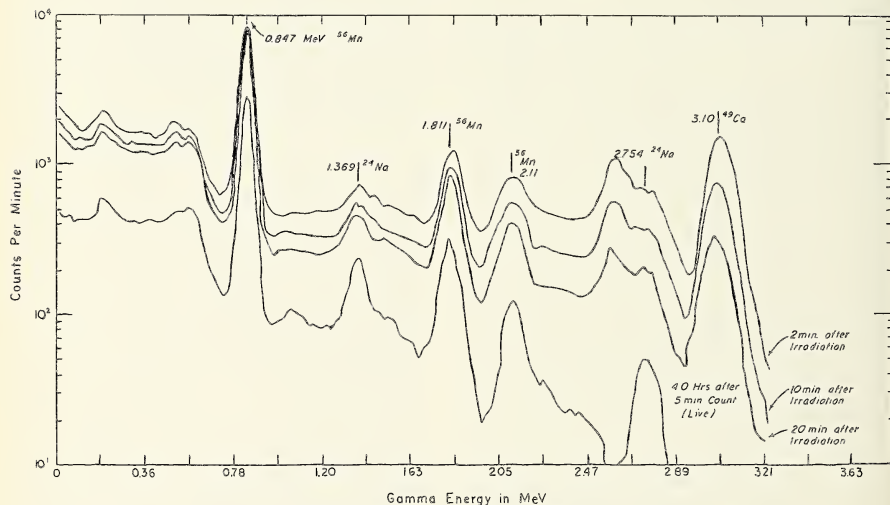
3/ L = Middle to lower portion of lock chamber

4/ living only around sump holes

METAL CONTENT OF THE NAIAD SHELL AND ITS RELATIONSHIP TO SEX AND AGE¹

Linda D. Saville* and Sandra S. Sterrett*

GAMMA SPECTRUM OF A SAMPLE AFTER A 5 MINUTE IRRADIATION



adapted from Merritt (1974)

Fig. 1. Gamma spectrums of a naiad shell sample after a five-minute irradiation showing the radioactive decay two minutes, 10 minutes, 20 minutes and four hours after irradiation.

Naiades are sessile filter-feeding animals and deposit their shells in characteristic annual layers. They are also known to deposit certain metals in the CaCO_3 crystal lattice (Turekian and Armstrong, 1960; Nelson, 1966). These characteristics make them good candidates for biological monitors of heavy metal pollution in our rivers and streams.

Before their reputation as a monitor can be established much preliminary work on the natural

variation in the shell content of metals due to age, sex, formation year and species must be determined. This is the work in which we are currently engaged. Specifically, in the part of our study represented here, we looked at metal differences in relation to sex and age in *Ambiema plicata* (Say, 1817) and *Quadrula quadrula* (Rafinesque, 1820).

All naiades used were collected from the Muskingum River at Lowell, Ohio, and thus the environment

¹ This study was funded by the Water Resources Center with the assistance of the Ohio State University's Nuclear Reactor Lab and Museum of Zoology.

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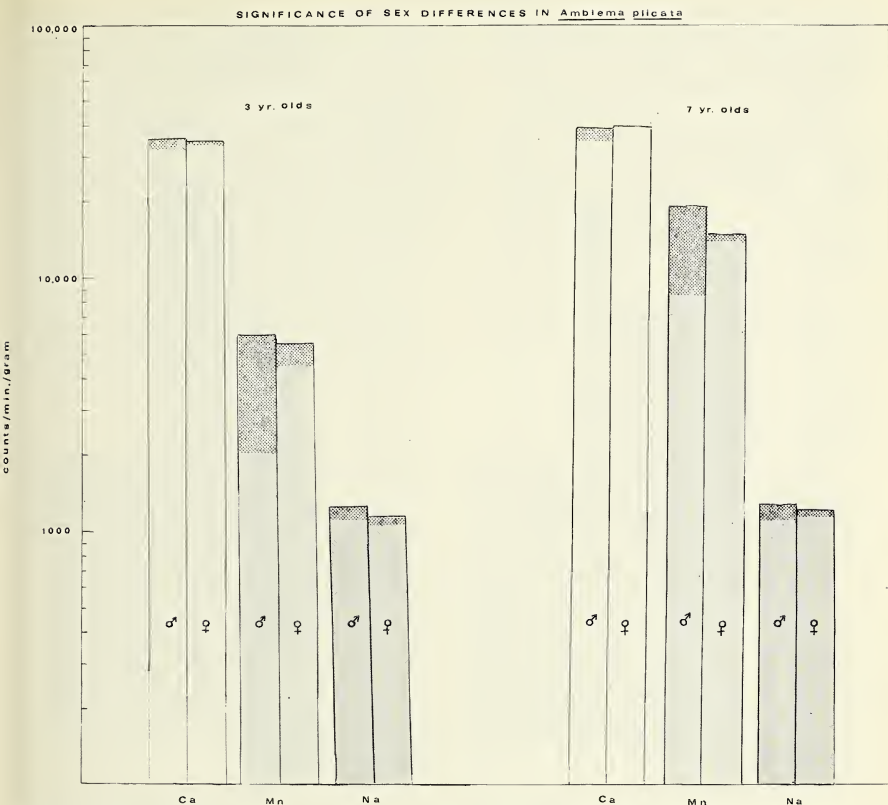


Fig. 2. Comparisons of the Ca, Mn and Na levels in two different layers from seven-year-old *A. plicata* specimens; one laid down in 1969 when the animals were three years old and one laid down in 1973 when the animals were seven. Information based on five males and two females. The stippled area represents the range of metal content values.

was eliminated as a variable. The shells were separated into annual peripheral nacre layers (Sterrett and Saville, in press), and each layer was analyzed for metals by neutron activation (Heath, 1964). The detection system used was a NaI(Tl) crystal and a 400 channel pulse height analyser.

Samples were irradiated for five minutes to determine the presence of short-lived nuclides and for four hours to detect longer lived nuclides. Since the four-hour irradiation results have not yet been analyzed this paper concerns only the five-minute irradiation results. Ca, Mn and Na were found in all samples. The amounts of the metals present in each sample are represented in the form of counts per minute per gram, a value proportional to the concentration of the metal in the shell.

Sex differences were tested by using two different layers from seven-year-old *A. plicata* specimens; one laid down in 1969 when the animal was three years old and one laid down in 1973 when the animal was seven. The results are based on five males and two females (see fig. 2). Such a small sample size makes definite conclusions difficult, but in this test sex differences did not seem to be significant. Significant sex differences would not be expected in the three-year-old samples since the animals were almost certainly not sexually mature at this age (Stein, 1973). The fact that sex differences seem insignificant in both seven- and three-year-old samples from the same individual lends support to the possibility that sex differences are not important. Mn, the most variable of the three metals (see ranges, stippled area

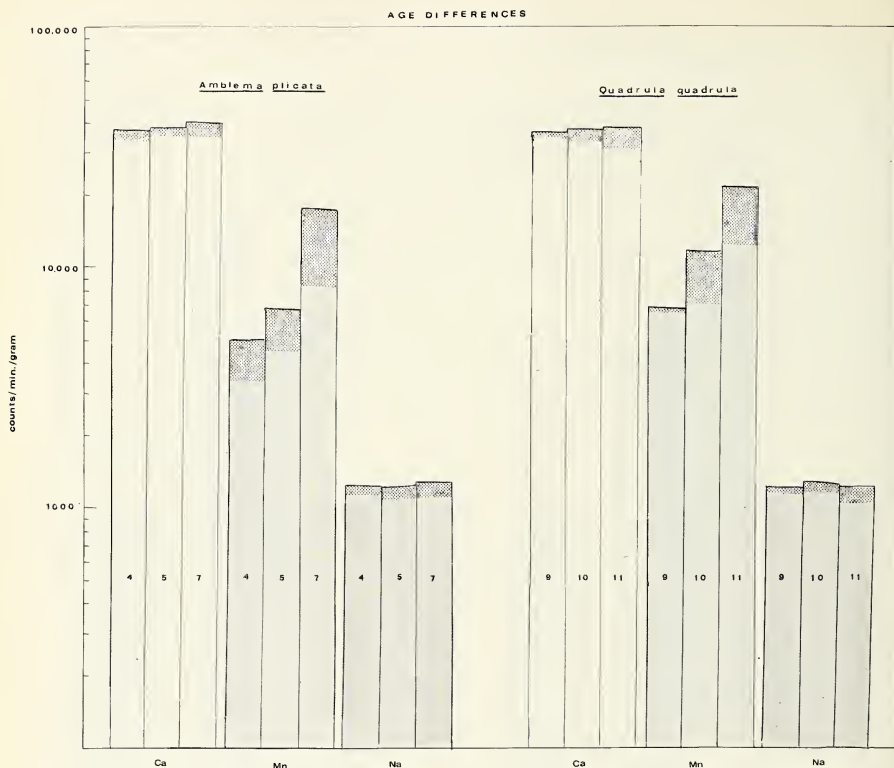


Fig. 3. Comparisons of Ca, Mn and Na levels in four-, five- and seven-year-old *A. plicata* specimens and nine-, 10- and 11-year-old *Q. quadrula* specimens. Information is based on four four-year-old specimens, three five-year-old specimens, seven seven-year-old specimens, four 10-year-old specimens and four 11-year-old specimens. The stippled area represents the range of metal content values.

in fig. 2), also would be expected to show sex differences plainly, if they existed, and does not. In a study of Mn content of gastropod shell, sex was not seen to be significant (Merlini, et al., 1965). Since it is probable that sex makes little or no difference in the ability of the individual to deposit either Ca, Mn or Na in its shell, sex was disregarded as a variable in the remainder of our analyses.

Individuals of *A. plicata* of four, five and seven years old and *Q. quadrula* of nine, 10 and 11 were tested for age differences (see fig. 3). Ca and Na differences appear to be insignificant in all cases, while Mn differences appear to be significant. In both species Mn levels increase with increasing age. Merlini, et al., (1965) found that Mn content increased with shell size (i.e. with age) in specimens of *Unio*. Nelson (1961) suggests that differences in the metal content

of naiaid shell related to age may be due to surface to volume relationships. Since young animals have a greater surface to volume ratio, ionic exchange is more rapid and metals would have a greater chance of escaping back into the environment. He also suggests that differences in growth rates with increasing age may lead to metal concentration differences.

Ca and Na levels seem to change little with age, although fig. 3 suggests that Ca levels do seem to increase slightly with age. Ca levels would be expected to be closely controlled regardless of age since the vast majority of the shell is made up of CaCO_3 . That Ca levels are quite consistent has been demonstrated (Nelson, 1961). Na levels in an animal are also usually under quite strict control. Mn on the other hand, may be less carefully controlled. In noting the ranges of Mn levels (fig. 3) we found our

data support this supposition.

So far our work suggests differences in metal levels are more closely related to age than to sex, and that sex is probably not a significant factor in this work.

Quite a bit of work is yet to be done. The analysis of our four-hour irradiations will yield information on metals with longer-lived nuclides. We can then see if this information matches the results already obtained for sex and age differences. Further age and sex studies will be carried out on older and younger specimens, and achieving (hopefully) better ratios of male to female. Studies of differences between species are also underway. Analyses of prismatic, periostracum and laminar nacre are being planned to determine if metals show up equally well in all shell layers.

After inherent differences of the shell's metal concentrations are fairly well established, water samples and shell layer samples can be correlated to see how well the shell reflects the metal content of the water environment.

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CHARACTER WEIGHTING IN LAND SNAIL CLASSIFICATION

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One of the most common disputes in systematic literature concerns the relationships between taxa. One specialist uses character "A" to indicate close similarity, while another specialist maintains that character "B" indicates a different grouping. How we should select and evaluate characters for systematic analysis is at the center of biological theorizing by systematists in the 1970's. Studies based on mollusks lag far behind studies on other groups in terms of attempting to cope with these problems.

This report attempts to survey briefly the basic data sets that have been used to classify land snails, to indicate major gaps in our knowledge, and then to describe one way in which selection and weighting of characters can be approached. It is not an attempt at

an exhaustive review, but a very preliminary outline to stimulate thought. It deliberately does not try to catalog or categorize current studies.

Because of its many and obvious features, plus ease of preservation, the shell of snails has been and continues to be used extensively in classification. From an initial division (Linné, 1758) into *Helix* and *Bulimus* on the basis of shape, progressively more detailed features have been studied and utilized. Férussac (1821-2) cited the peripheral shape, sculpture, presence or absence of apertural barriers, and umbilical contours as criteria in separating groups. Beck (1837) showed an intuitive genius in recognizing shell similarities and differences that led to his dividing the land snails into 126 "sections".

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Many of these genera are used today in very nearly their original sense. Building on this basis, Albers (1850) and von Martens (1860) coped with the rising number of land snail species by expanding the number of genera, sections and families. All of this work was conchological. It is still a rare situation where features enabling *identification* of a biospecies cannot be discovered in the shell. Frequently, however, the initial discovery that more than one species was represented among a series of populations occurred because data from other organ systems, behaviour, genetics, biochemistry, or breeding experiments showed that reproductive isolation existed. Subsequent study usually finds shell differences from which identifications can be made.

Currently the shell microstructure is just starting to be examined. The study of suboptical features in sculpture, periostracum, shell layers, bonding of the organic and calcareous layers, details of embryological development of the shell, and shell repair mechanisms, all can be expected to yield basic data of great potential systematic utility.

Robert Hooke (1665) called the jaw of a snail its "teeth", illustrating this as one of the first biological objects examined through a microscope. It was not until the time of Mörch (1860, 1865), however, that a systematic evaluation of the jaw in land pulmonates was undertaken. Mörch's division of the land mollusks into major groups based on jaw shape, structure and ridging is now only of historical interest. The convergent nature of jaw shape and gross sculpture is generally accepted, although the classification of Pelseener (1906) still was based on Mörch's system. Studies of jaw microsculpture, chemical composition, and micro-architecture could yield highly useful data. Casual observations (Solem, unpublished) with the scanning electron microscope (SEM) suggest that major differences exist in the jaws of land mollusks.

Scattered observations on the radula occurred in the early to mid-1800's, but it was the monumental work by Troschel (1856-1893) that established the utility of the radula in distinguishing genera, species and even families. Continued use of radular data, from information obtained through optical microscopes, gradually is being replaced by studies using the SEM.

The first illustrations of land snail genitalia were by Swammerdam in the mid-1600's. Although not published until 100 years later (Swammerdam, 1752), they set a level of knowledge and quality not equalled until nearly 1900. Exquisite illustrations by Leidy (1851) slightly preceded pioneer works by Schmidt (1855) and Moquin-Tandon (1855), who used the genital system in systematic studies. While Fischer (1883) gave high systematic weight to the number of genital openings, it remained for Pilsbry (1893) to articulate the basic outline of systematically important features. His (Pilsbry, 1893, p. 389) recommendations that one should observe the

"Shape of the penis and presence or absence of internal papilla and external appendix; presence or absence of flagellum or epiphallus; point of insertion of the retractor muscle and of the vas

deferens. Upon the female system should be noticed the absence or presence and form of dart sacks, darts, mucous glands or appendicula; the length of the spermathecal duct; the form of the caeca of the ovotestis and whether they are embedded in the liver or free; and finally whether the right eye-peduncle is retracted between the branches of the genitalia or to the left side"

set a standard that held essentially unchanged until about 1960. Since then a number of workers have begun examining finer details of the genital system, analyzing homologies and functional significance, and attempting to develop some ideas as to directionality of observed changes. Only a few taxa have been sampled and this work is in purely initial stages of development.

Use of the pallial cavity configurations and excretory system in land snail classification dates from Semper and Simroth (1894) and Pilsbry (1900a, 1900b). Critical comments and expanded observations by Watson (1920), Wächtler (1934) and H.B. Baker (1955) have led to an ordinal level classification of the stylommatophoran land snails based largely on the organ complex. The data prior to the studies of Bouillon (1960) and Bouillon and Delhaye (1970) were based on gross dissection. A huge variety of taxa remain to be studied at the tissue and cellular levels of observation.

Study of the caudal mucus gland, foot grooves, and integument date from work in the 1890's, with Pilsbry (1896) assigning high significance to the foot grooves, although Watson (1920), Wächtler (1935) and H.B. Baker (1955) assigned somewhat lesser weight. The fine structure and functional significance of these structures still remain to be determined.

Work on the nervous system (Bargmann, 1930 and Van Mol, 1967), chromosome numbers (J.B. Burch, et. al.), karyotype analysis (Butot and Kiauta, 1967), and various studies on the molecular level (immunology, electrophoresis, protein evolution) are beginning to yield data of great potential value in systematics.

Unfortunately the tendency still prevails for each worker to focus on one set of characters and make sweeping conclusions concerning affinities of species based on one organ system. All too often the desirability of using data from a variety of systems is ignored. The examples of Semper (1870-1880), Pilsbry (1893, 1893-4, 1900a, 1900b, 1919, 1948), Watson (1915, 1920), Steenberg (1925) and the many contributions by H.B. Baker in which a variety of systems are studied still have not been adopted as standards. The recommendation of Pilsbry (1893-4, p. xxvii) that

"a natural (=phylogenetic) classification of Pulmonates should be based upon:

Organs of protection (Shell, mantle, integument of body).

Organs of locomotion (foot with pedal-grooves, tail gland, etc.).

Organs of reproduction (genitalia, comparative size of eggs, etc.).

Organs of nutrition (jaw and teeth, intestinal tract, kidney).

Nervous system (including sense-organs such as

tentacles, etc.),
Muscle system."

remains equally timely now.

As in systematic studies in most groups of organisms, the initial "whole organism" impressions concerning land snails in the late 1700's expanded into studies of organ systems through gross dissections, histological observations in the late 1800's and early 1900's on the tissue level with optical microscopes, cellular observations with new techniques of preparation and modern optical equipment in the mid-1900's, and recently into suboptical studies with transmission and scanning electron microscopes. Simultaneously with the latter approaches, biochemical studies have commenced. The electron microscope and biochemical studies require sophisticated equipment available only at a few centers and training in technology that until very recently was not available routinely to graduate students. The resulting almost overwhelming mass of potential data in every field undoubtedly has served to focus attention on the problem of how to evaluate conflicting evidence.

In the early 1960's, the phenetic approach, based on the Adansonian idea that "all characters are of equal value", enjoyed a brief vogue. Realization that many characters are correlated, demonstrations concerning the prevalence of convergent evolution, and the growing triumphs of functional morphology in understanding the origin and significance of structures led a return to phyletic analysis. Formerly handled on a relatively intuitive basis, this school of systematics considers that "some characters are *important* in interpreting directions of evolutionary change, while others are relatively *trivial*". The obvious questions relating to this view are "How do you tell which character is important and which is trivial?", "If two organisms have the same character, is this the result of common origin or convergent evolution?", "Are the similarities and differences shown by species being studied the result of convergence, divergence, or independent origin?"

The pheneticists claim that it is virtually impossible to answer these questions. Certainly it is difficult to do so, but at least an approximation is possible. The approach I am attempting to use in understanding the patterns of land snail evolution, and hence higher systematic categories, involves trying to separate different levels of evolutionary change. Implicit in this approach is the concept of "progress", that is, change in ecological relationships over time, leading to "success" measured by group survival, diversification in ways of living, and/or persistence in a taxonomic sense.

The most significant level of evolutionary change, and presumably the rarest, involves a shift in adaptive zones, such as the movement from water to land, changes in water conservation patterns on land, evolution from shelled mollusk to slug, and possibly the shift from cell content sucking to detritus consumption. A second, and much more common level, involves the process of diversification, whether in an ecological vacuum or as a more gradual process. The change from terrestrial to arboreal life, herbivore to

carnivore, moist to semi-arid habitat dweller, detritus to "live plant" (algal sheets, fungi, plants) feeder, and major shifts in niche position are included in this level. Finally there is the most common level of change, involving sympatric species interactions. The well established concepts of competitive exclusion, character displacement, niche specialization, and effects of predator selection will result in changes at the population or species level. They also initiate the beginnings of shifts leading to diversification or a real change in adaptive zone.

All the characters observed in a group of snails, whether the characters be shell, anatomical, cellular, behavioral, or biochemical, must be thought of in terms of functional significance to the snail, particularly in comparison with potentially related species. It must be asked "Could this behavioral/genetic/biochemical/anatomical/shell/radular variation be the result of selection caused by local species interactions; does it permit a shift in way of living compared with similar species; is the character common through a group, present in a few, or unique to one species; do the species all have very similar "life styles" or is one species "different" in its ecological role; is the different type simply an "odd ball" or does it presage a "new way" of living."

In theory this approach would require an incredible amount of work, since reviewing all characters would be a monumental task. In practice, the high degree of character correlation within a group means that a relatively small number of features vary extensively, a major grouping of characters serves to separate clusters of species (genera and families), and, when dealing with closely related taxa, only a few species show evidence of exploring "new ways of living".

Organisms do not exist in a static world, but constantly interact with other species. In recent years dramatic advances in understanding species and community ecology have occurred. A "marriage" of the data from systematic observations and the accumulated ecological data offers perhaps the best hope for a real advance in understanding the evolution and coping with the diversity of the 25,000 land snail species.

We are only beginning to study this diversity, the newly available electronic tools and biochemical techniques have been used by a handful of workers, and many lifetimes of study are needed. Yet without a framework of reference, in the absence of a clearly defined way in which to evaluate the significance of the observed variations, it will be extremely difficult, if not impossible, to develop a classification and understanding of land snail evolution with predictive values. The major practical advantage of phyletic classification lies in its ability to predict many features of the behaviour, feeding, possible parasites, and general ecology of "unknown species" showing structural affinity to a group. We do not, at present, have a truly phyletic classification of the land snails, but hopefully the methodology briefly outlined above can lead to the development of one.

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THE PLEUROCERIDAE AND UNIONIDAE OF THE MIDDLE FORK HOLSTON RIVER IN VIRGINIA

David H. Stansbery* and William J. Clench*

The Middle Fork Holston River is one of several headwater streams of the Tennessee River system. It has its origin in a number of cold springs just above the village of Groseclose in the Ridge and Valley Province of the Southern Appalachians of western Virginia. From this point it flows in meandering fashion southwest down its valley, joining the South Fork Holston River at what is now the head of South Holston Impoundment. This man-made modification is responsible for the elimination of most forms of river life from the impounded part of the South Fork; but the impoundment appears to have had little effect on the Middle Fork except for a few miles near its mouth. Other factors which may have a deleterious effect on the Middle Fork mollusk fauna include domestic and industrial wastes from the communities of Marion and Chilhowie and the silts and pesticides associated with valley farming.

Favorable factors for molluscan life include the soluble limestone bedrock of the entire length of the Middle Fork valley. Topographic maps show the valley dotted with sinkhole depressions. The forested slopes on either side, in combination with abundant rainfall, provide a relatively constant source of cool, clear water throughout the year. The high gradient and coarse substrate of the stream bed result in frequent riffles or shoals which maintain high levels of dissolved oxygen and keep the particulate food of the filter-feeding bivalves available in suspension.

Considering these factors, it is not surprising that the Middle Fork Holston and many other upper Tennessee system tributaries have (or had) such an unusual abundance, in both species and numbers, of river mollusks. What is surprising is that Reed Creek, a tributary of New River, which flows northeast out of this same valley and whose headwaters interdigitate with those of the Middle Fork, had only a very few species of river mollusks. Quite obviously, the fauna of a river system depends on more than favorable habitat. Whether or not ancestral forms of any given species had access to a stream system clearly appears to be a major factor to be considered in each such problem.

It is the primary objective of this study to determine what species of pleurocerid snails and unionid bivalves live in the Middle Fork Holston River and to learn the pattern of distribution of the various species within the stream. This information provides a base for an equally interesting problem, that of determining what factors are responsible for the origin and maintenance of these patterns of distribution. We hope that this report will provide inspiration and insight to others who are also interested in solving the problems of ecological zoogeography.

Several early studies (Say, 1825; Lewis, 1871; Pilsbry and Rhoads, 1896; and Beopple and Coker, 1912) dealt with the Holston River in general terms or the Holston proper below the confluence of the forks. The earliest known specific reference to Middle Fork mollusks, however, was that of Adams (1915: 19) in his study of *Io fluvialis* (Say, 1825). Adams notes that

"The probabilities are that *Io* does not occur in the Middle Fork, nor in the South Fork, above the junctions of the two streams near Barron, Va. I examined the streams at this place . . . but found no evidence of them upon the rocky shoals which abound in the Middle Fork near its mouth . . ."

We also found no trace of *Io* in this study.

In his study of the naiades of the upper Tennessee system, Ortmann (1918: 610) made 2 collections on the Middle Fork in Smyth County, Virginia. At Marion, about 10 miles below the source, he found two unionid species. At Chilhowie, about 20 miles below the source and slightly more than halfway to the mouth, he was successful in taking 12 species. The air-distance from Marion downstream to Chilhowie is only about 10 miles, while the increase in unionid diversity revealed in Ortmann's collections is a factor of six. This fact, in view of our recent experience on the North Fork Holston River (Stansbery and Clench, 1974), led us to carefully sample the Middle Fork every few miles from its origin through Marion to Chilhowie, and to make enough collections below Chilhowie to give us the distribution patterns of the species involved.

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Collections were made along the main course at each reasonable point of access in 1968, 1970, 1973, and 1974. The approximately 40 mile distance was sampled at 21 sites. Four of these sites were re-sampled on a second or third occasion to compensate for such factors as high water, poor lighting, or lack of time, on the first visit. We made a sincere effort to determine the entire mollusk fauna at each site although this sometimes required spending all or most of a day at a single collection site. All specimens collected were either living or represented by fresh shells unless otherwise indicated. No evidence was found of the previous existence of species not listed here. We found the fauna to consist of 4 pleurocerids and 18 unionids, a total of 22 species.

A comparison of the Middle Fork faunal list with that of the North Fork, 23 species, shows the number of species present to be nearly the same. An examination of species composition, however, reveals some interesting differences. Species absent from the Middle Fork but recorded for the North Fork include *Strophitus undulatus tennesseensis* (Frierson, 1927), *Fusconia edgariana* (Lea, 1840), *Toxolasma* (= *Carunculina* l. *lividus* (Raf., 1831) and *lo fluvialis* (Say, 1825)). All of these species were recorded only for the lowermost 3-4 miles of the North Fork suggesting that the Middle Fork retains its headwater environment for a much greater distance downstream. This is further indicated by the presence of *Lasmigona holstonia**, long known as a headwater species (Ortmann 1918: 557), at 3 of the 4 uppermost sites of the Middle Fork. There are no records of this species for the North Fork.

The pleurocerid species of the two forks are the same except for the time-honored records of *lo* from the lowermost North Fork at Saltville. An examination of the distribution of these snails reveals patterns, however, that are quite different from those that were expected. *Goniobasis simplex* was found at all of the upper 14 collection sites in the Middle Fork while in the North Fork it was limited to only 2 of the upper 4 sites. It was also found that *Pleurocera uncialis* did not become part of the fauna until the 11th site with *Spirodon patula* and *Anculosa subglobosa* appearing at the 12th site. This evidence further emphasizes the persistence of headwater conditions far downstream in the Middle Fork.

The arrangement of Middle Fork species in a distributional table reveals in graphic form the sudden change in diversity suggested by Ortmann's 2 collections (made in 1912 and 1913) and further supported by the observations noted above. Species diversity varies from 1 to 3 throughout the first 11 sites of the Middle Fork, a distance of over 20 miles. Over the same distance the North Fork achieves a diversity of 10 species. The 13th site on the Middle Fork, however, shows a dramatic increase in diversity to 13 species. Ortmann's collections indicate that this condition is of at least 50 years' duration.

Whatever the conditions responsible for this persistent headwater habitat in the Middle Fork, they are effectively, and rather suddenly, reduced at this point about midway between Marion and Seven Mile Ford. The transition zone in both streams is indicated by

the point where *Goniobasis simplex*, the uppermost headwater pleurocerid, is joined by *Spirodon patula*, another headwater species and where *Villosa iris nebulosa* and *Villosa vanuxemi* are joined by *Pegias fabula*, *Pleurobema oviforme*, and *Medionidus conradicus*. This transition occurs just over 5 miles downstream from the source of the North Fork and about 17 miles downstream from the source of the Middle Fork.

The topographic maps of the area were examined in the hope that some physiographic feature or features might provide a probable answer. The most apparent differences are the narrower upper valley, greater habitation, and extensive Karst topography of the Middle Fork valley. Since this distribution pattern existed at the time of Ortmann's collections (1912 and 1913) before Marion and Chilhowie had grown to their present size, factors associated with recent population increases do not appear to be responsible. The number of solution depressions combined with vegetated slopes and a relatively long narrow valley, at least down to Marion, may well reflect a stream generously provided with cold ground water. This could readily result in lower mean stream temperatures and the maintenance of headwater habitat for an unusually long distance downstream. The physiography of the valley and the sudden increase in mollusk diversity independently place the area of change midway between Marion and Chilhowie.

While the above may explain the absence of certain species from upper Middle Fork, it does not explain the presence of *Elliptio dilatatus*, a common species here or *Epioblasma* (= *Dysnomia*) *walker*i, one of the rarest forms present.

The understanding of the nature and origin of faunal distributions, even in stream headwaters, is fraught with many difficulties. Not the least of these is our ignorance of many, perhaps most, of the factors involved. Certainly aquatic organisms and the streams in which they live have evolved together. It may well be that our crude efforts to understand the relationships existing between them today may eventually lead to a far better understanding of both than we could have achieved through the study of each independently.

* See table for authors and dates of species if not given in text.

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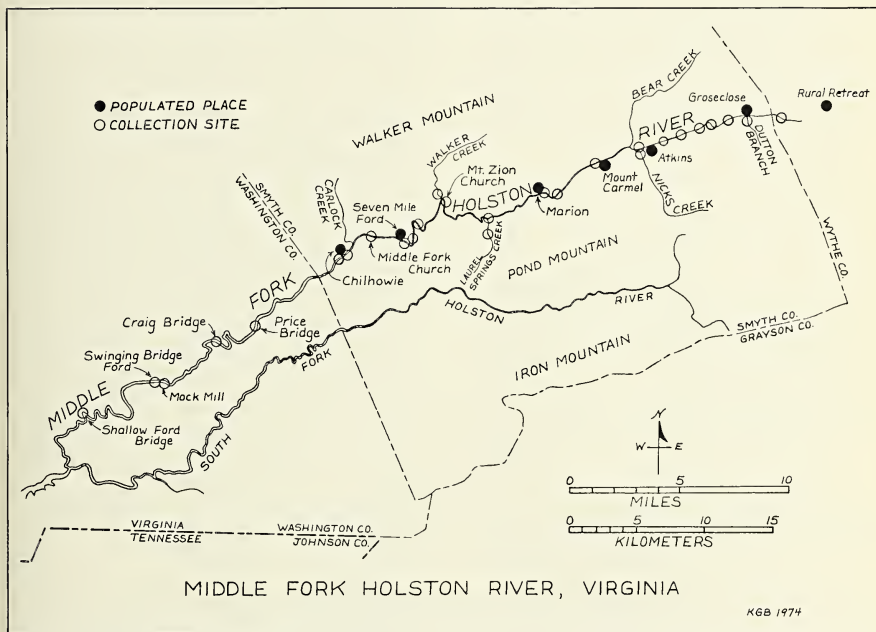
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SPECIES RECORDED

SPECIES RECORDED	Frequency of Occurrence																					Range of Distribution
	2.5 mi W Rural Retreat, 1974	1.0 mi WSW Groseclose, 1970	1.6 mi WSW Groseclose, 1970	2.1 mi WSW Groseclose, 1970	3.1 mi WSW Groseclose, 1970	4.1 mi WSW Groseclose, 1970	Atkins, 1970	Mount Carmel, 1970	Marion (E Edge), 1970	Marion (Chillhowie Street) 1970	2.5 mi WSW Marion, 1970	Mt. Zion Church, 1970	5.6 mi WSW Marion, 1970, 1974	Seven Mile Ford, 1974	Middle Fork Church, 1970	Chillhowie, 1968, 1973, 1974	Price Bridge, 1970	Craig Bridge, 1968, 1974	Mock Mill, 1970	Swinging Bridge Ford, 1974	Shallow Ford Bridge, 1968, 1970	
FAMILY UNIONIDAE																						
Subfamily Anodontinae																						
<i>Alasmidonta marginata</i> Say, 1818.																						
<i>Alasmidonta viridis</i> (Rafinesque, 1820).																						
<i>Pegias fabula</i> (Lea, 1838).																						
<i>Laemigona costata</i> (Rafinesque, 1820).																						
<i>Laemigona holstonia</i> (Lea,1838).																						
Subfamily Amblesinae																						
<i>Fusconia barnesiana</i> (Lea, 1838).																						
<i>Lexingtonia dolabelloides</i> (Lea, 1840).																						
<i>Pleurobema oviforme</i> (Conrad, 1834).																						
<i>Elliptio dilatatus</i> (Rafinesque, 1820).																						
Subfamily Lampsilinae																						
<i>Psychobranchus fasciolaris</i> (Rafinesque, 1820).																						
<i>Psychobranchus subentium</i> (Say, 1825).																						
<i>Actinonaias pectorosa</i> (Conrad, 1834).																						
<i>Medionidius conradicus</i> (Lea, 1834).																						
<i>Villosa iris nebulosa</i> (Conrad, 1834).																						
<i>Villosa vanuxemi</i> (Lea, 1838).																						
<i>Lampsilis ventricosa</i> (Barnes, 1823).																						
<i>Lampsilis fasciola</i> Rafinesque, 1820.																						
<i>Epioblasma walkeri</i> (Wilson and Clark, 1914).																						
Total Naiad Species Recorded	0	1	2	1	0	0	0	2	2	1	0	2	9	7	9	11	9	12	10	13	6	
FAMILY PLEUROCIDAE																						
<i>Pleurocera uncialis</i> (Haldeman, 1841).																						
<i>Goniobasis simplex</i> (Say, 1825).																						
<i>Spirodon patula</i> (Anthony, 1860).																						
<i>Anculosa subglobosa</i> (Say, 1825).																						
Total Pleurocid Species Recorded	1	1	1	1	1	1	1	1	1	1	2	4	4	4	3	3	3	3	2	2	0	

x = this study, 1968-1974

* = Subfossil

o = Ortmann, 1912-1913

A TECHNIQUE TO SEPARATE THE ANNUAL LAYERS OF A NAIAD SHELL (MOLLUSCA, BIVALVIA, UNIONACEA) FOR ANALYSIS BY NEUTRON ACTIVATION¹

Sandra S. Sterrett* and Linda D. Saville*

Trace metals discharged into our streams and rivers, even though usually in small concentrations, are often toxic to some of the aquatic life. Because the concentrations are so minute and vary greatly with time, detection of the source is not feasible by ordinary chemical monitoring. In such situations analysis of an aquatic organism that would concentrate the metals to a measurable level and integrate the variations in concentration over its growing season can indicate the presence of toxic metals. If the indicator organism is relatively immobile, analysis of specimens from different sites can help locate the effluent responsible.

Naiades are relatively immobile, are widely distributed (Simpson 1914) and are known to concentrate many trace metals in their shells (Girardi and Merlini 1963). But what makes the naiad an especially good indicator organism is the fact that the shell is deposited in annual layers (Chamberlain 1930). If these layers could be isolated and analyzed individually, annually integrated trace metal concentrations could be determined for a specific location as far back in time as the age of the naiad would permit.² This study was undertaken to develop an accurate shell separation technique and an appropriate analytical technique to make the historical information in the naiad shell available.

Activation analysis was chosen as our analytical technique because of its sensitivity to metals and because it requires only a small amount of sample material. For activation analysis of naiad shells, at least 0.5 gram of sample material is required (Merritt 1974).

Before developing a method for separating the naiad shell into annual layers, an understanding of shell formation was necessary. A naiad shell actually has four layers formed by different areas of the

mantle and each layer has its own annual layers. Two thin outer layers are formed by the free ventral edge of the mantle: the outer protein membrane, the periostracum, and under the periostracum, the crystalline prismatic layer (Wilbur 1964). The layer forming the bulk of the shell, the peripheral nacre, is deposited by the surface of the mantle ventral, or peripheral, to the pallial line. The thin laminar nacre is deposited by the surface of the mantle dorsal, or central, to the pallial line (Nelson 1964). (See Fig. 1.)

DIAGRAM OF CROSS SECTION OF SHELL AND MANTLE

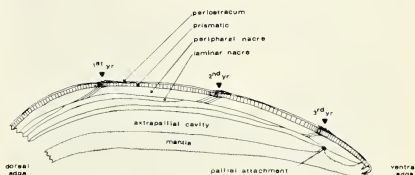


Fig. 1. A diagram of the shell and mantle showing the four shell layers with their annual layers in cross section.

The mantle first deposits the periostracum which serves as an organic matrix on which CaCO_3 is crystallized into the three crystalline shell layers (Bevelander and Benzer 1948, Taylor et al., 1969).

As in trees, the annual layers in naiades are a result of seasonal changes in growth rate. During periods of low temperature, the mantle withdraws and ceases shell formation (Coker et al. 1921). Repeated interruptions in shell formation during the spring and fall result in an area of discontinuity visible as a dark line. The greater amount of periostracum at this border results in an area higher in protein than the other parts of the shell. Theoretically, if the shell is baked

² NOTE: Some naiades commonly live 15-25 years and some have been estimated at 40-60 years (Isely 1931, Stansbery 1961).

¹ This study was funded by the Water Resources Center with the assistance of The Ohio State University's Nuclear Reactor Laboratory and Museum of Zoology.

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at high temperatures, the protein of the periostracum will ash and not the CaCO_3 , leaving a weak spot or crack that delineates the part of the shell formed in a single growing season.

Utilizing these facts, Nelson (1964) described a baking method for separating annual layers. He cut each valve in half medially and ashed it in a muffle furnace at 400°C for four hours. The annual rings of each layer were then separated with a scalpel. A second separation technique was described by Pahl (1967). He also cut each valve in half medially but ashed it in a muffle furnace at 500°C for 10 minutes and separated only the nacre into the annual layers using a sharp probe and forceps.

Although both Nelson and Pahl sawed the shells in half, we attempted to separate the layers on a whole baked valve. The layers, however, stuck together at the edges just anterior and posterior to the umbo. When pressure was applied to separate the layers, the whole shell crumbled. Sawing the shell in half removes one edge enabling better separation. We found that if the valves are cut from the umbo to the ventral edge at both the anterior and posterior margins, the wedge produced separates far better than either the whole valve or a half. (See Fig. 2.) The shells were cut with an automatic saw using a carbundum-charged blade which produced a smoother cut and was a great deal easier than a hack saw.

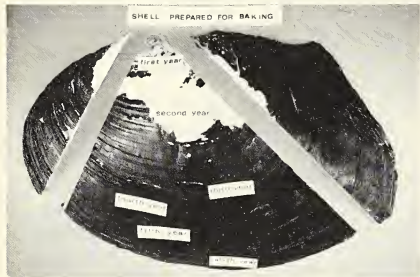


Fig. 2. One valve of a *Lasmigona complanata* (Barnes 1923) sawed in preparation for baking.

The shells baked by the shorter method separated much more easily than those baked by the long method. Those wedges baked longer developed many separations within an annual layer and tended to crumble. The prismatic layer was much easier to separate from the peripheral nacre in the wedges baked for 10 minutes. We found that shells separated well even when baked for five minutes at 600°C . (See Fig. 3.)

Because the prismatic layer is much too thin and does not develop cracks at the annual layers, it was not used for analysis. The laminar nacre (formed within the pallial line) is too thin in some species and tends to flake apart easily. On the other hand, the layers of the peripheral nacre usually weighed 0.5 gram except for the first year of growth and could be separated easily with forceps and a sharp probe.

Samples of peripheral nacre were prepared from five species collected in the Muskingum River in Ohio: *Lasmigona complanata* (Barnes, 1823), *Quadrula quadrula* (Rafinesque, 1820), *Ambelma plicata plicata* (Say, 1817), *Obliquaria reflexa* (Raf., 1820), and *Potamilus alatus* (Say, 1817). Of these, *P. alatus* and *L. complanata* were the easiest to separate.

By cutting the valves into wedges and baking them for five minutes at 600°C , the peripheral nacre can be separated into annual layers. An analysis can be made of each layer, except the first, producing an historical record of metal concentrations which were present in that naiad's environment. Analysis of naiad shells collected before and after the installation of a suspect pollutant could determine the resultant change in water quality. Using recently collected naiades, the difference between metal concentrations above and below a suspect effluent could be determined. Analysis of a recently deposited layer could indicate the presence of hazardous elements before they reach a damaging concentration, and indicate the source and the range downstream. The full potential of information available from naiad shells remains to be determined.



Fig. 3. The peripheral nacre from the center wedge shown in Fig. 2. The wedge was baked in a muffle furnace at 600°C for five minutes and the layers separated with a needle and forceps.

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SHELL GROWTH RATES OF THE COMMON MUCKETS *ACTINONAIAS LIGAMENTINA* (LAMARCK, 1819) COMPLEX

Mary E. St. John*

The growth of the *Actinonaias ligamentina* (Lamarck, 1819) complex (figure 1), has not been studied, even though this complex is very common in many rivers of midwestern North America. This investigation is part of an attempt to discover the basic growth patterns of populations of this complex in localities over the range. All of the collections used are in the Ohio State University Museum of Zoology.

Data on growth in length were collected from specimens from seven rivers. These were the Grand River, Ontario (55 specimens), Sandusky River, Ohio (100 specimens), Walhonding River, Ohio (111 specimens), Green River, Kentucky (120 specimens), Powell River, Tennessee (100 specimens), Clinch River, Tennessee (120 specimens), and the Kiamichi River, Oklahoma (90 specimens). The length, defined as the maximum antero-posterior dimension, of each annual ring on each shell was measured. The mean length for each year of growth was calculated and these means were used to construct the bar graphs.

The most rapid growth rate occurs during the second or third growing season in all the populations, with the possible exception of those in the Kiamichi River. The shells of the Kiamichi *A. l. gibba* (Simpson, 1900) were so badly eroded around the umbo, even in specimens collected alive, that accurate determination of the earliest growth rates was nearly impossible. All the populations showed the most rapid decrease of growth rates between the fourth and ninth years. In the tenth year and beyond, a slower, steady decline was established.

As shown in the bar graphs, figure 2, the most rapid growth rate, an average 20.3 mm per year, is found in the *A. l. carinata* (Barnes, 1823) from the Sandusky River. *Actinonaias l. carinata* from the Grand River maintained a rapid rate of growth for a longer period of time than those of the other rivers. Shells from these three samples were larger than those of the other rivers. The largest specimen was an individual at least 40 years old from the Sandusky River, with length 175 mm, width 86 mm, height 101 mm, and weight 1017 grams. The right valve of this shell measured 19 mm thick near the ventral margin. The slowest average growth rate during the first three years was 12 mm per year, and occurred in the *A. l. ligamentina* (Lamarck, 1819) from the Powell River. Beyond the fourth year, the *A. l. carinata* of the Green River and the *A. l. gibba* of the Kiamichi River maintained the slowest growth rates, dropping to an average of 0.3 mm per year in the oldest shells. The shells from the Green River were the most variable in size and shape of all the populations studied.

Among shells approximately 20 years old, the average total length was 151 mm in the Sandusky River, 136 mm in the Grand River, 128 mm in the Walhonding River, 121 mm in the Powell River, 121 mm in the Clinch River, 104 mm in the Kiamichi River, and 100 mm in the Green River.

Some of the difference in total length attained is due to differences in the shape of the shell of the three varieties, as illustrated in figure 1. *Actinonaias l. ligamentina* is relatively square, with a shorter length

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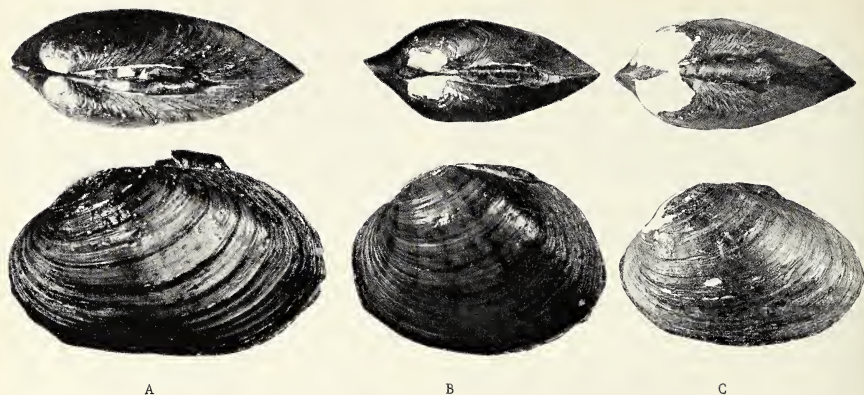


Figure 1. The Common Mucket, *Actinonaias ligamentina* (Lamarck)

- A = *A. l. carinata* (Barnes) OSUMZ catalogue number 10509.54 from the Grand River, Ontario. L = 138 mm, H = 77 mm, W = 53 mm, age = 18 years.
- B = *A. l. ligamentina* (Lamarck) OSUMZ catalogue number 16759.156 from the Clinch River, Tennessee. L = 105 mm, H = 75 mm, W = 45 mm, age = 13 years.
- C = *A. l. gibba* (Simpson) OSUMZ catalogue number 32825 collected alive from the Kiamichi River, Oklahoma. L = 106 mm, H = 67 mm, W = 47 mm, age = 12 years.

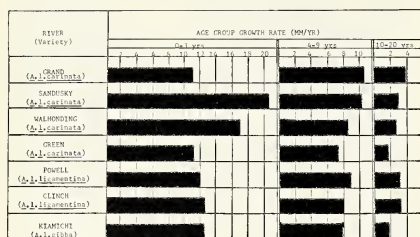


Figure 2. Mean Growth Rates of *Actinonaias ligamentina* (Lamarck) in Seven Rivers.

relative to the height (the dorsoventral dimension) when compared with the other two. *Actinonaias l. carinata* and *A. l. gibba* are about equally elongate.

Some of the difference in growth rates and total size attained is related to environmental conditions, especially the concentration of calcium and of bicarbonate. The most rapid growth rate occurs in the Sandusky River specimens of *A. l. carinata*, most of which were collected in one area, about one mile south of Upper Sandusky, Ohio. This is evidently a local environment with very favorable conditions for this species. The site is a run, downstream from several miles of alternate riffles and runs, with water from a few inches to about 4 ft deep. Stansbery (personal communication, 1973) reports that he has

never seen it dry or not flowing in over 40 years of observation. The current is moderate, and the bottom is coarse sand and gravel with some soft silt in the run and gravel and cobbles in the riffle. Each living naid is about two-thirds buried in the gravel bottom areas. Water chemistry tests in September, 1972 (St. John, 1973) revealed calcium averaging 230 ppm and bicarbonate averaging 210 ppm. These calcium and bicarbonate levels were higher than those found in any of the other rivers studied. In the Green River, the calcium content, measured in June, 1971, averaged 76 ppm, and the bicarbonate content averaged 82 ppm. Radlinski (1972: 295) gave water chemistry for the Kiamichi River; calcium averaged 1.3 ppm and bicarbonate averaged 8.8 ppm.

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STUDIES OF BIVALVE LARVAE USING THE SCANNING ELECTRON MICROSCOPE AND CRITICAL POINT DRYING

R.D. Turner* and P.J. Boyle*

INTRODUCTION

The study of minute organisms using the Scanning Electron Microscope (SEM) is now routine but the quality of the results is directly proportional to the care with which specimens are selected and prepared. Consequently the techniques used and the care taken in cleaning, drying and mounting specimens are most important for successful SEM work.

The purpose of this paper is to point out some of the problems that may be encountered working with bivalve larvae and to present techniques which we have found to be successful. Our research involves problems which we have found can best be accomplished and illustrated using the SEM: 1) Studies on the variation in the sculpture and hinge structure of the valves of pediveliger larvae and their importance in systematic work both on an inter and intra specific level 2) Studies of larval transport by currents based on the ability to identify larvae to species 3) The morphology of the foot, velum, apical "flagellum", cilia and microvilli of pediveliger larvae to aid in an understanding of their function and their possible use in systematic work.

PREPARATION OF SHELLS

Bivalve larvae form a major component of the plankton (Thorson 1946; Thiede 1974) and though the percentage varies greatly with season and locality, large numbers are routinely taken in plankton tows. Most of these larvae, unfortunately, remain unidentified or are determined only to family or possible genus. McBride (1914) believed that the veliger larvae of bivalves were so similar that they could not be distinguished. Since that time many papers on bivalve larvae have been published, the more notable recent ones being those of Jorgensen (1946), Rees (1950) and Loosanoff, and Davis (1963), Loosanoff, Davis and Chanley (1966), Chanley and Andres (1971). All of these authors, however, depended largely on shell shape and size to distinguish species, the hinge structure and sculpture generally being beyond the ability of the instruments then available to examine and

photograph them. The shells of bivalve larvae seldom reach 400 microns in length, most are strongly convex and many are nearly spherical, characters which make them nearly impossible to photograph through the light microscope.

Turner and Johnson (1969) and Scheltema (1971) using the SEM illustrated two species of terebratulids which showed marked differences in sculpture and hinge structure. We have now examined 6 additional species of terebratulids and 3 pholads using the SEM and on the basis of these micrographs it is apparent that the sculpture and hinge structure can be effectively illustrated and that larvae of species within the same genus can be readily distinguished. All of the larvae which we have used in our SEM studies are reared in the laboratory from known parents so that identification to species is positive.

Cleaning the tiny larval shells is one of the major problems in SEM work. The soft parts can be removed from preserved or relaxed living specimens by teasing with fine needles, soaking in a weak base or digestive enzyme, or by sonicating. These methods are not always successful, particularly if the valves are tightly closed, and many of the specimens may be lost in the process. If living larvae are available feeding them to small anemones is an effective way of cleaning them. The anemones digest the soft parts and egest empty, gaping valves. The sea anemones, all less than 1 cm in diameter, are kept in a series of petri dishes and the larvae are pipetted directly onto the tentacles. To insure complete removal of all soft tissue the anemones should not be over fed, so no more than five larvae should be given at one time. The gaping valves should be picked up immediately on release from the anemones before they become covered with bacteria and debris. (Culliney, Boyle and Turner, 1975).

To further clean the valves they should be washed 5 or 6 times by gently shaking them for 3-4 minutes in a small vial of distilled water to which a minute drop of Teel or other detergent can be added. After each wash the water should be decanted or pipetted off the valves immediately after they settled to the bottom. The process should then be repeated an

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equal number of times using 75 to 80% alcohol. The specimens can then be stored in 95% alcohol as recommended by Thiriot-Quievreux (1972).

If the shells, on inspection with a compound microscope, look completely clean they can be mounted on metal stubs using double coated tape or other adhesives, coated with gold-palladium and examined under the SEM.

This process, however, may be unsatisfactory for three reasons: 1) The valves are seldom clean enough for the high magnifications possible with the SEM 2) Mounting individual valves on the stub is extremely time consuming and specimens may be damaged or pick up dirt in the process 3) Specimens mounted on double coated tape or other media available at the present time are, in a matter of a few months, enveloped by the medium and so lost. Consequently, rare specimens or those needed for a permanent museum record should not be examined with the SEM.

The procedure used in our studies began with the cleaning of the shells as outlined above and storing them in 95% ethyl alcohol. Final preparation for SEM examination consisted of rinsing the specimens in distilled water, placing them in an ultra filtration cell (Amicon Model 12 without the stirrer) using a PM 30 Diaglo ultra filter. The filter was numbered for identification purposes with a fine Esterbrook Perm-color pen, and placed in the bottom of the ultrafiltration cell. The cell was filled 1/2 to 2/3 with distilled water, the specimens pipetted in and the top clamped into place. The cell was connected to a nitrogen tank and then submerged in a water bath in a 3M sonicator (Plate 1, fig. 5). After sonicating for about 1 minute, the nitrogen was turned on gradually and the water was slowly replaced by nitrogen. As soon as the nitrogen began to bubble out of the vent on the bottom of the cell it was removed from the bath and the nitrogen allowed to continue to pass through the filter until it appeared dry. This deposited the specimens on the surface of the plastic filter and they adhered firmly to it. The filter was removed, after drying the outside of the cell, and examined under a dissecting microscope. If it was still damp some rearranging of the specimens was possible using a fine needle. When the filter was dry (this is very important for successful coating) it was attached to the stub with conductive paint and placed in the sputter coater, the pressure raised to 200 psi and the specimens coated with gold-palladium for about 1-1/2 minutes. The specimens were then ready for examination with the SEM. After examination and photographing, the filter was removed from the stub and stored in a small plastic box as a permanent part of the collection (Plate 1, figs. 1-2).

The advantages of this system are: 1) It is relatively easy to examine populations of larvae, 2) The plastic filters do not "consume" the specimens, so the picture is not the only permanent record of the material examined thus permitting the examination of rare specimens 3) It is possible to re-examine the specimens years later.

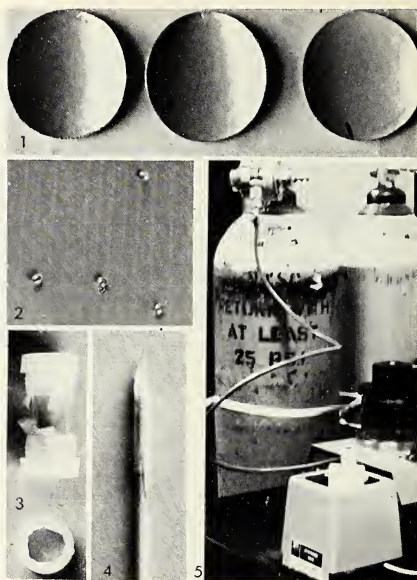


Plate I

Fig. 1. Filters with specimens attached after examination with SEM and ready for storage in the collection.

Fig. 2. Close up of filter showing coated larvae.

Fig. 3. Capsule made from pyrex tubing, plastic caps and nyltex for use in the critical point dryer.

Fig. 4. Pick-up tool made from applicator stick and double coated tape.

Fig. 5. Ultrafiltration cell in sonicator and attached to nitrogen tank.

PREPARATION OF SOFT TISSUE

The examination of soft tissue with the SEM is relatively new and to date has been confined mainly to bacteria, protozoa, phytoplankton, small invertebrates and isolated tissue (Anderson, 1951, 1956; Hollenberg and Erickson 1973 - review and bibliography; Paerl and Shimp 1973; Por and Bromley 1974). An effective and commonly used procedure for preparing soft tissue for examination with the SEM is by critical point drying, the procedure used in this study. To our knowledge this is the first time relaxed bivalve larvae have been examined in this

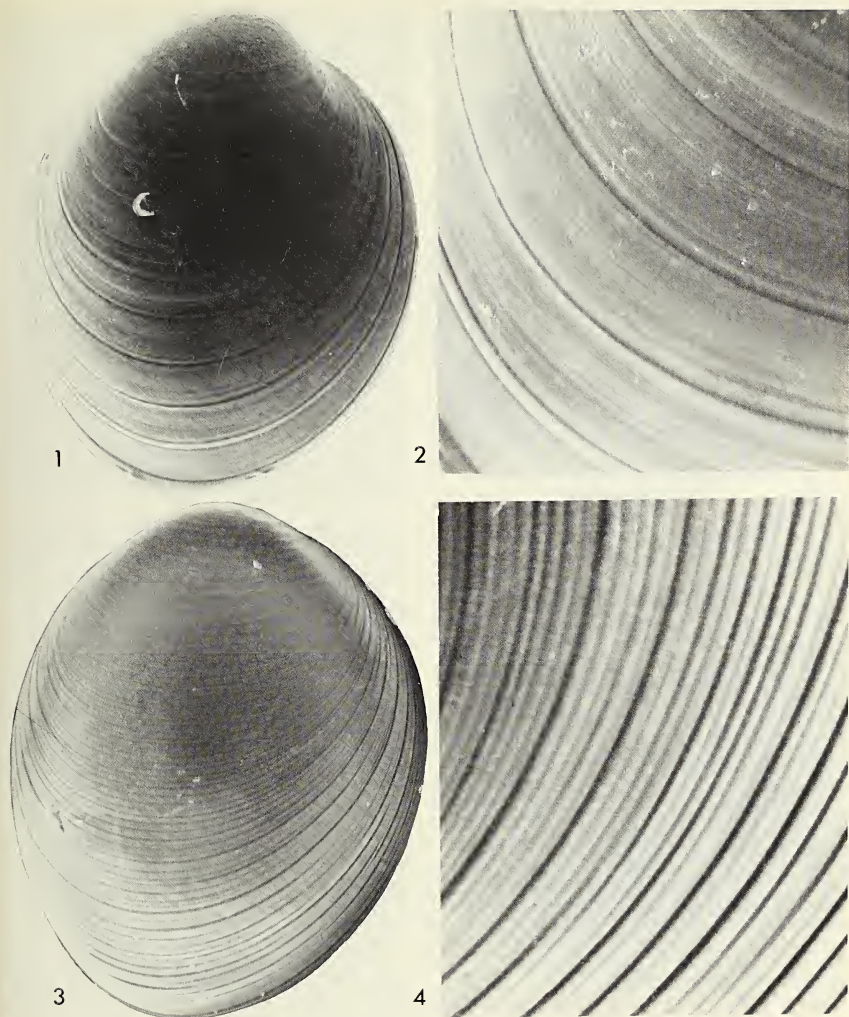


Plate II

Fig. 1. *Teredo navalis* Linnaeus, valve of pediveliger (360 X).

Fig. 2. Sculpture of the same (1000 X).

Fig. 3. *Lyrodus pedicellatus* (Quatrefages), valve of pediveliger (260 X).

Fig. 4. Sculpture of the same (1000 X).

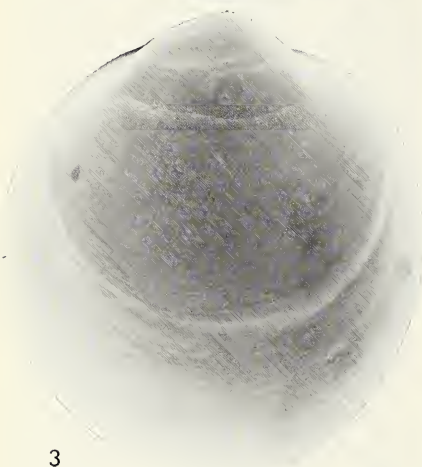
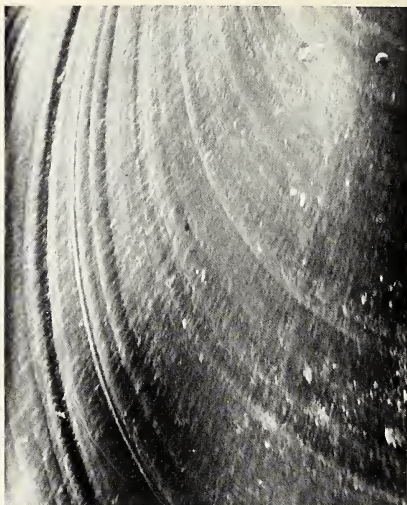
**Plate III**

Fig. 1. *Nototeredo knoxi* Bartsch, valve of pediveliger (600 X).

Fig. 2. Sculpture of same (2000 X).

Fig. 3. *Teredo furcifera* von Martens, valve of pediveliger (300 X).

Fig. 4. Sculpture of same (3000 X).

way. The following procedures were used in preparing of the specimens illustrated on Plate 4.

Relaxation of specimens. To obtain fully relaxed specimens 100-200 active larvae were placed in a petri dish with 50 ml sea water and 8 ml of 7.5% $MgCl_2$ made with distilled water. They were left undisturbed for 1 hour, or until most larvae were swimming, then another 8 ml of the $MgCl_2$ solution was added and within an hour the specimens were fully relaxed. Experience, however, has shown that the reaction of larvae differ. *Lyrodus pedicellatus* relaxed readily with $MgCl_2$ but not with propylene phenoxetol while *Martesia striata* relaxed in both solutions. Experimentation is needed to find the best relaxant for a given species. When the larvae were fully relaxed the solution was pipetted off leaving only enough to cover the specimens. Further immobilization was accomplished by placing the dish in the refrigerator for 15 minutes and then in the freezing compartment until the first ice crystals began to form at the edge of the dish. This must be watched carefully because the specimens must not be allowed to freeze.

Fixation. The specimens were fixed by flooding them with chilled 2% glutaraldehyde buffered with sodium cacodylate (0.025 M in seawater). We dissolve 1.07g sodium cacodylate in 200 ml of 1 μ filtered sea water; add 8.0 ml of 25% glutaraldehyde to 92 ml of the buffered sea water. This solution was changed 5 times at 5 minute intervals. At this stage the specimens can be stored for a few weeks unfrozen in the refrigerator.

Dehydration. Dehydration of the specimens is accomplished by running them up through a series of miscible liquids to liquid CO_2 (such that at no time is there a liquid-liquid phase boundary which would distort the specimens). This is accomplished in 3 steps. 1) The alcohol series. The water is gradually replaced by alcohol to 100%. Concentrations, time intervals and the number of changes per concentration are shown in Table 1. The alcohol solutions from 7.5% to 50% were made with 3.5% sodium chloride solution adjusted to pH 8 which is isotonic

with sea water to prevent osmic shock to the fixed tissue. Alcohols from 75% to 95% were made with distilled water to prevent the precipitation of salts on the surface. If necessary, specimens can be stored for a short time in 95% alcohol. 2) The amyl acetate series. The alcohol was gradually replaced with amyl acetate, (which is miscible with both alcohol and liquid carbon dioxide) according to Table II. After the last change in 100% amyl acetate the specimens were transferred to a container made to fit the "bomb" chamber of the critical point dryer. This container was made from pyrex tubing fitted at each end with a plastic cap from which the center had been removed. A disc of nylon screen (nytex) of a mesh size small enough to contain the specimens was placed over the ends of the tube and the plastic cap pushed firmly into place. The tube containing the specimens to be dried was submerged in a bottle of 100% amyl acetate until it was placed in the critical point dryer.

Replacement of amyl acetate by liquid CO_2 . After checking the critical point dryer to be sure that everything was functioning properly the container of specimens was removed from the jar of 100% amyl acetate, drained briefly on a piece of paper towel to remove excess liquid and sealed quickly into the bomb which must be at a temperature of 25°C or below. For a discussion of the principle behind the functioning of a critical point dryer, the critical temperature and pressure, see Anderson (1951, 1956). There are now several models of CPD's on the market, each with its own manual of operation and this should be studied carefully before the specimens are placed in the bomb chamber.

After removal of the specimens from the dryer they should be mounted immediately in as dry and clean an atmosphere as possible so that the specimens do not pick up moisture or dirt. If they cannot be mounted immediately they should be left in the container and placed in a dessicator.

Attachment of specimens to the stub. Two dissecting microscopes were used for this process: under

Table I - Time Table - The Alcohol Series

% ETOH	Time (min.)	# of Changes	Notes
7.5	1	1	Made with 3.5% NaCl solution adjusted to pH 8
7.5	20	1	" "
15	1	1	" "
15	20	1	" "
30	1	1	" "
30	20	1	" "
50	1	1	" "
50	20	1	" "
75	5	6	Made with distilled water unbuffered
85	5	8	" "
95	5	10	" "
			Can store for short period
100	6	3	

Table II - Time Table - Amyl acetate Series

% Amyl acetate	Time	No. of Changes
20	1 min.	1
20	6	1
40	6	1
60	6	1
80	6	1
100	6	3

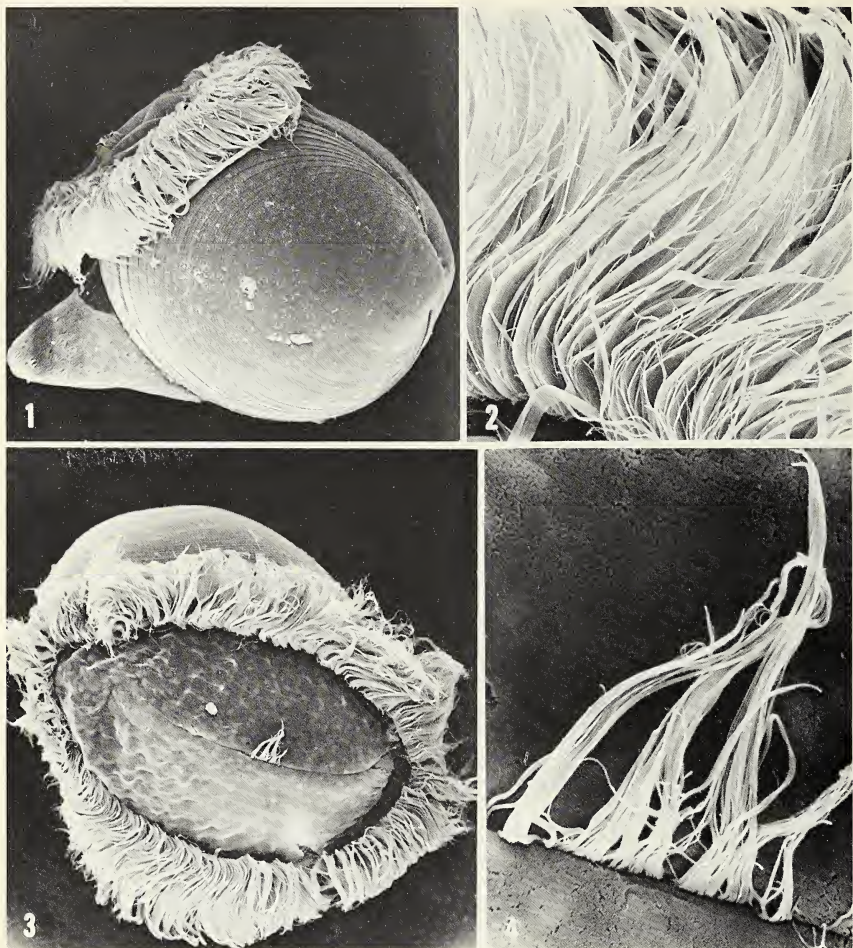


Plate IV — Critical point dried *Lyrodus pedicellatus* (Quatrefages).

Fig. 1. Side view of entire larvae with foot and velum extended, note the cilia covering the foot (180 X).

Fig. 2. Enlargement of cilia on the velum (1000 X).

Fig. 3. Anterior view of vellum showing the 'apical flagellum' (200 X).

Fig. 4. Enlargement of the 'apical flagellum' (2000 X).

one we had the loose dried specimens and under the other the stub with double coated tape on which they were to be mounted. The specimens were transferred from the tube to a slide a few at a time by gently tapping the side of the tube. They were picked up one at a time using a piece of double coated tape which had been cut to a fine point, wrapped around the end of a small applicator stick and then trimmed to the finest possible point. By gently touching the point of the double stick tape to the dried specimen it was easily picked up, transferred to the stub and placed in the desired position without damage to the specimen. The specimens should be distributed on the stub so that they do not interfere with each other during coating or when viewing with the SEM. The best medium to date for the mounting of critical point dried specimens is double coated tape because it allows time for the careful transfer and placement of specimens not possible with the quick drying liquids. The disadvantage is that it will eventually "consume" the specimens. However, if, after examination, the stubs are kept in a dessicator in a cool place they should last for a considerable time. When all specimens were mounted on the stub the tape was attached to the stub with conductive paint to reduce charging. It was then placed in a dessicator and kept in a cool, dry place until ready for coating.

Coating and examination. The specimens were coated using a mini sputter coater and viewed with a JEOL Inc. Scanning Electron Microscope model JSM 35.

CONCLUSIONS

Variation in sculpture of four species of Terebrinidae is shown on Plates 2 and 3. The high magnification possible with the SEM clearly shows the finest growth lines on the valves. Since we know the exact age of these laboratory reared larvae, careful counting of these growth lines should give us some indication of their periodicity.

The most exciting result from the examination of the critical point dried larvae was the demonstration that the apical flagellum is not a single element but a bundle of large cilia (Plate 4).

ACKNOWLEDGEMENTS

We are most grateful to Mr. T. Huber and Mr. A. Kabaya of JEOL U.S.A. Inc. for their kind help and the use of a JSM35 Scanning Electron Microscope; to the Amicon Corporation for their interest in our problem and the loan of an ultrafiltration cell and to the Oceanic Branch, Office of Naval Research for support of our research under Contract Number No. 14-67A-0298-0027 with Harvard University. We also thank Mr. B. Calloway for aid in preparation of specimens and Dr. J. Culliney and Dr. K. Boss for reading the manuscript.

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ABSTRACTS OF PAPERS READ

THOMAS SAY — AMERICA'S FIRST MALACOLOGIST

R. Tucker Abbott *

Commentary on the life of Thomas Say of Philadelphia, who was one of the first malacologists of America.

* Delaware Museum of Natural History, Greenville, DE 19807

DREDGING FOR SCALLOPS OFF VERO BEACH

Kirk W. Anders*

A slide presentation of a dredging operation in the Summer of 1971, operating out of Vero Beach. Information regarding other species of mollusks which were collected during the operation was given.

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A COLLECTING TRIP WITH LERMOND IN THE FLORIDA EVERGLADES

William J. Clench*

(Abstract not available.)

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EVOLUTION OF THE HYDROBIIDAE:
AN ANALYSIS OF TWO DISTINCT LINEAGES

George M. Davis*

Existing taxonomic arrangements of gastropods considered to be Hydrobiidae result from the analysis of shell, radulae, opercula, and verges. Analyses of all morphological traits and their ontogeny leads to the conclusion that European and North American taxa allied to Hydrobia are in a lineage (Hydrobiinae) apart from that involving taxa from South America, South Africa, Australia, and the Orient. The latter taxa are currently grouped in the subfamilies Triculinae and Pomatiopsinae. Characters of importance in addition to the above mentioned traits are the ontogeny of the female reproductive system, mechanisms by which sperm enter the female reproductive system, and geographic origins of the faunas.

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DR. JARED P. KIRTLAND, CLEVELAND'S FIRST MALACOLOGIST,
AND SOME OF HIS CORRESPONDENCE

Ralph W. Dexter*

Dr. Jared Potter Kirtland (1793-1877), under the influence of his grandfather Dr. Jared Potter, studied nature and collected shells as a boy in Connecticut. In 1810 he joined his father, founder of Poland, Ohio (near Youngstown), where he collected mollusks from the Mahoning River. After his medical training at Yale University (M.D., 1815) and practice of medicine in Connecticut, he returned to Ohio in 1823 to practice medicine and continue his study of Ohio natural history. In 1829 he discovered separate sexes in the Unionidae, and in 1840 discovered the byssus in larval stages of that family. During 1836-37 he was in charge of Zoology for the First Geological Survey of Ohio and published an official report in 1838. His principal interests were the mollusks, fishes, and birds. While engaged in medical practice, teaching in medical schools, founding an academy and museum of natural sciences, and conducting experimental work in horticulture in the Cleveland area, he continued his studies on Ohio freshwater and land mollusks. He was on the Board of Managers for the Smithsonian Institution and corresponded with many naturalists throughout the country. Two letters sent in 1841 to Dr. D. Humphreys Storer, an officer and curator at the Boston Society of Natural History, relate to collecting bivalves in Lake Erie and Dr. Kirtland's praise for the work on midwestern mollusks by John Gould Anthony.

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INTRODUCED MOLLUSCS

Dee S. Dundee*

(Abstract not available.)

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AN ECOLOGICAL INTERPRETATION OF NUDIBRANCH
ZOOGEOGRAPHY IN THE NORTHWEST ATLANTIC

David R. Franz*

The nudibranchs of the northwest Atlantic coast of North America comprise two distinct faunal groups: a small component of endemic temperate species; and a larger group of amph-Atlantic boreal (amphiboreal) species. The latter confer a decided boreal cast to the North American fauna. South of New York, the relative importance of the amphiboreal component declines, and temperate species dominate. South of Cape Hatteras, nudibranch diversity increases with the influx of subtropical and Caribbean species.

About 70% of New England nudibranchs are amphiboreal species. Analysis of faunal overlap between New England and other locations in the North and Northeast Atlantic using a numerical similarity coefficient (the Simpson Index) indicates significant similarity with locations from West Greenland to the Netherlands, and northern Norway to England. On the Brittany coast, similarity with New England becomes insignificant. Thus, the New England nudibranch fauna is essentially a subset of the larger boreal Atlantic fauna. Distributions of amphiboreal species may have been continuous across the North Atlantic arc during the post-pleistocene "hypsihermal" period. However at present, populations of less cold-tolerant species are absent from Iceland and West Greenland.

Two ecological correlates of amphiboreal nudibranchs are: (1) broad feeding niches as measured by the number of prey species; (2) specialization on transient prey species of low biomass. An analysis of feeding data for North Atlantic nudibranchs shows that in England, the amphiboreal component of the fauna is more prey-diverse than the fauna as a whole. In New England, this same component appears to be less prey-diverse, reflecting the absence in American waters of many potential alternate prey species. If many of the amphiboreal nudibranchs of New England are relatively recent colonizers of the northwest Atlantic, the quality of prey diversity may have been the singularly most important requirement for success in a new geographical area where the number of potential prey species is much reduced.

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THOUGHTS ON THE FUNCTIONAL MORPHOLOGY AND ECOLOGY OF PATELLIFORM MOLLUSKS

Elaine Hoagland*

The patelliform shell has evolved independently in several lines of mollusks. This is not a single convergence, but is composed of a least three major trends; adaptation for grazing on rocky shores (chitons; Archaeogastropods), adaptation for life on vegetation in creeks and ponds (pulmonates), and modification for life as subtidal, sedentary, filter feeding organisms (Calyptreaeacea; oyster-like bivalves). The general benefits and liabilities of the patelliform shell were reviewed for all mollusks. Ecological parallels between the oysters (including the Anomiacea and Chamacea) and the Calyptraeacea were related to morphological adaptations in the groups.

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PHOSPHOLIPIDS OF TWO VERONICELLIDS

M.L. Ibanez* and D.S. Dundee*

Phospholipids of *Veronicella ameghini* and *V. floridana* were isolated and compared. In addition, the fatty acids were isolated and identified for each of the phospholipids. No qualitative differences were found although quantitative differences were detected between the two species. The authors report the presence of cardiolipin, phosphatidyl ethanolamine, phosphatidyl choline, and sphingomyelin with small amounts of phosphatidyl serine and phosphatidyl inositol also present.

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MOLLUSKS IN LITERATURE, ETC.

Morris K. Jacobson*

Popular myths about mollusks and the uses poets, novelists, seers, and prophets have made of mollusks were discussed. Some remarks on the trials of museum curators and some slides referring to Charles Wright (1811-1885) were also included.

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SHIPBOARD OBSERVATIONS ON THE BIOLOGY OF GYMNASOMATOUS PTEROPODS FROM THE SOUTH ATLANTIC AND ANTARCTIC OCEANS¹

C.M. Lalli*

The biology of several gymnosomatous pteropods from the South Atlantic and Antarctic Oceans was studied during the Hudson 70 Expedition, sponsored by the Canadian Department of Energy, Mines and Resources.

Feeding experiments were conducted with *Spongiobranchaea australis* d'Orbigny, the most abundant gymnosome in subantarctic surface waters. In the laboratory, this gymnosome fed upon live specimens of the thecosomatous pteropod, *Clio antarctica* Dall, by completely extracting the prey body from its shell. The only recognizable gut contents from rapidly preserved specimens were gizzard plates of *Clio* spp., confirming that this is a natural food of *S. australis*.

Bipolarity was re-examined in the thecosomes *Spiratella* ("Limacina") *retroversa* (Fleming) and *S. helicina* (Phipps), which show very little anatomical difference from their northern counterparts. However, distinct external anatomical differences distinguish the clionid gymnosome of Antarctic waters from *Clio* *limacina* (Phipps) of the northern hemisphere. A slimmer body shape, proportionately longer head and larger foot lobes, the distinct neck region dorsal to the wings, and the prominent papillae of the larval anterior ciliary band are among those features of the Antarctic clionid which immediately distinguish it from *Clio* *limacina* and justify the usage of the name *Clio* *antarctica* E.A. Smith. Results of feeding experiments demonstrated that *Clio* *antarctica* feeds upon *Spiratella* *retroversa* and *S. helicina*, as does *Clio* *limacina* in northern waters.

¹ Research supported by Grant No. A5248 from the National Research Council of Canada.

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PINCTADA MARGARITIFERA (LINNÉ) USED IN FIJIAN BREAST PLATES

Glenn A. Long*

This paper was read under the title "Identification of *Pecten* sp. (?) Used in Fijian Breast Plates" making reference to the use of mistaken nomenclature for shell material in ethnographic objects. Our intention is to provide accurate identifications of ethnoconchological materials.

Pinctada margaritifera (Linné) is the species of pearl shell used in all Fijian breast plates which were examined at first hand. That identification was made on evidence of the characteristic combination of size, color, growth and muscle scar configuration in the examined species. Color variations were examined in the hope that such variances might lead to the determination of collecting localities of shells used in the breast plates. So far, these studies have led to no conclusions.

Species identification was a simple procedure, but discovering and defining ethnological use and anthropological significance of the shell used in breast plates is far more difficult. Anthropological attribution of the breast plates should tentatively be broadened to include Fiji and Tonga both on the basis of motif characteristics of inlaid whale ivory and with regard to accounts of the geographical distribution of lineages whose head-men possessed these ornaments.

Further, there are unanswered questions regarding the origins of intrinsic value attributed to pearl shell. In addition, due to the appearance of distinct artistic styles in the manufacture of these breast plates we are obliged to inquire as to the significance of potential tribal dynastic influence over yet unidentified artists.

Nevertheless, accumulated data suggest that breast plates made with whale ivory alone or with shell were produced over a relatively short time, roughly commensurate with the first century of continuous contact by trade and exploration by European and American seafarers. This leads to the question of whether drastic economic change and increased accumulation of wealth by certain Fijian or Tongan chieftains was the cause of shell and whale ivory breast plate production. Did white men, in fact, stimulate a modification in the fabrication of breast plates which heretofore was thought to be endemic?



Fiji or Tonga Breast Plate (Shell) *Pinctada margaritifera*, whale ivory.

Accession number

55.251.160

Gift of Mr. Alan Wurtzburger, Baltimore Museum of Art.

* The Baltimore Museum of Art, Baltimore, MD 21218

AROAPYRGUS COSTARICENSIS HYDROBIIID SNAIL HOST OF PARAGONIMIASIS IN COSTA RICA

E.A. Malek*, R. Brenes* and G. Rojas*

The systematics of the hydrobiids of Central and South America are still unstable. Early reporting on this group placed several species under a few genera, common among which are *Paludina*, *Hydrobia*, *Amnicola* and *Littoridina*. Later reports considered also *Pterides*, *Idiopyrgus*, *Lyrdes*, *Potamopyrgus* and *Cochliopa*. Thanks to the works by Baker (1930), Morrison (1946), Taylor (1966) and Thompson (1968) the status of some genera and species was clarified, and still more work is needed.

Interest in the study of this group of mollusks increased in recent years because it became known that they are of significance in the transmission of several species of lung flukes of humans and other mammals in Central and South America, rather than the melaniid snails which had been suspected to act in this capacity.

Aroapyrgus costaricensis is here described from Costa Rica as the snail intermediate host of *Paragonimus mexicanus* in that country. It was collected from Balsa de Atenas and San Mateo (Province of Alajuela), from Tres Rios (Province of Cartago) and from Rincon de Osa (Province of Puntarenas). It had been placed earlier under *Hydrobia* by Morch, *Amnicola* by von Martens, and even recently under *Pyrgophorus*. Information in this paper deals with its systematics, morphology, laboratory maintenance and ecology of its habitats, with special reference to the capacity of the snail in transmitting the infection to freshwater crabs, which are the second intermediate hosts of paragonimiasis in Costa Rica, as well as in other parts of Central America, and in South America. In the morphological features emphasis is placed on the shell, on the verge in the male, the pallial oviduct in the female which is modified to form a brood pouch in this viviparous snail, on the radula, shape of the gill and number of gill filaments. The closest species to *A. costaricensis* is *A. alleei* described from Panama by Morrison (1946).

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WEST COAST MALACOLOGISTS, A CANDID PORTFOLIO

James H. McLean*

Portraits of malacological personalities taken at meetings of the Western Society of Malacologists were shown.

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REDISCOVERY OF VERRILL'S NUDIBRANCHS AND SEVERAL NEW ADDITIONS TO THE OPISTHOBRANCHS OF NEW ENGLAND

M. Patricia Morse*

During the last ten years a number of species of opisthobranch molluscs have been found which have not been studied since their original descriptions were recorded in the literature. *Coryphella stimpsoni* Verrill and *C. salmonacea* Couthouy have been rediscovered and their direct development patterns recorded. Recently an 80 mm specimen of *Dendronotus robustus* Verrill was taken in Beverly, Massachusetts and placed in a tank at the Marine Science Institute in Nahant. The nudibranch was maintained on *Tubularia* sp. and an egg mass was deposited.

In Waquoit Bay, a large population of *Doriopsilla pharpa* Marcus was found feeding on the boring sponge, *Cliona celata*, which bores into oyster shells. This nudibranch appears to have been transplanted from south of New Jersey, where it was described by Marcus, and has established a breeding population along the Southern Cape Cod Coast due to aquaculture practices.

Additionally, two new species of opisthobranchs have been described from our laboratory. First is *Okenia ascidicola* Morse which is found feeding on the tunicate, *Mogula manhattensis*. The organisms bore a hole in the test of the solitary tunicate and proceed

to feed on the contents. They then crawl inside the test and take up residence. The second discovery was a new species of the order Acochlidacea, *Unela nahantensis* Doe. This is an interstitial opisthobranch found in the coarse gravel beach at the Nahant Marine Science Institute and its maximum length is 2.7 mm.

Year round studies and new techniques used for interstitial opisthobranchs have been important in increasing our knowledge of New England opisthobranchs. (Contribution number 34 from the Marine Science Institute, Northeastern University).

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ECOLOGICAL DISTRIBUTION OF LAND SNAILS IN THE CHIHUAHUA DESERT OF BIG BEND NATIONAL PARK, TEXAS.

W. Lloyd Pratt*

Land snail habitats within the park include the Rio Grande floodplain, desert ranges of Cretaceous limestone, and the wooded Chisos Mountains of Tertiary igneous rock. The desert land snail fauna of the floodplain and desert mountains is entirely separate from the montane woodland fauna: there are no species and only two genera of broad ecological amplitude common to both.

Two species are found on the floodplain. *Polygyra texasiana* (Moricand) is found around springs at Rio Grande Village and *Rabdotus alternatus* (Say) is generally distributed in the mesquite – seepwillow woodland of the floodplain.

Eight species are found in the desert mountains. *Rabdotus alternatus* (Say) is generally distributed in the shrub desert of the lower slopes and three species of *Holospira* (*H. hamiltoni* Dall, *H. yucatanensis* Bartsch, and *H. riograndensis* Pilsbry) inhabit rock ledges in the same habitat. *Succinea luteola* Gould, *Metastoma roemeri* (Pfeiffer), *Rabdotus dealbatus durangoanus* (Martens), and *Rabdotus pilsbryi* (Ferriss) are found in desert grassland on the flat tops of the ranges. The desert species seem to be obligate calciphiles and are absent from the largely igneous bajada of the Chisos Mountains.

Twenty-three species of the montane fauna inhabit a variety of wooded habitats in the Chisos Mountains: *Succinea* sp., *Cionella lubricella* (Porro), *Vallonia perspectiva* Sterki, *Pupilla hebes* (Ancey), *Gastrocopta pellucida* (Pfeiffer), *G. ashmuni* (Sterki), *G. pentodon* (Say), *Columella columella* (Benz), *Pallifera* sp., *Helicodiscus eigenmanni* (Pilsbry), *Punctum vitreum* Baker, *Radiodiscus millicostatus* Pilsbry and Ferriss, *Glyphyalinia identata* (Say), *Euconulus fulvus* (Muller), *Striatula meridionalis* (Pilsbry and Ferriss), *Hawaiiia minuscula* (Binney), *Pseudosubulina cheatumi* Pilsbry, *Thysanophora horni* (Gabb), *Microphysula ingersolli* (Bland), *Polygyra chisosensis* Pilsbry, *Humboldtiana chisosensis* Pilsbry, *H. edithae* Parodiz, and *H. agavophila* Pratt. R.H. Wauer has collected two additional montane species, an undescribed *Polygyra* allied to *P. chisosensis* and *Humboldtiana texana* Pilsbry, in a small area of stunted evergreen woodland on the Sue Peaks in the Dead Horse Mountains.

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THE SHELL IN CEPHALOPOD PHYLOGENY

Clyde F.E. Roper*

Cephalopods arose as a distinct Class of mollusks 400-500 million years ago. During most of their evolutionary history, cephalopods retained one of the primary molluscan features – a hard, external shell. The fossil cephalopods are a very large and diverse group of mollusks, whose diversity is expressed in a complex classification that is based on a single structure of the whole animal, the shell. In the absence of other preserved characters, the high degree of variation in the cephalopod shell through more than 400 million years of evolution has enabled paleontologists to distinguish more than 10,000 species.

Only during the last moment of geological time has the shell become incorporated internally with the structure of the mantle, until in Recent cephalopods the shell has lost its predominance as a primary phylogenetic character. Although the shell is an extremely

varied structure throughout the living cephalopods, animals that possess similar-looking shells are not necessarily closely related, based on more significant systematic characters. If a neontologist were limited to using only the shell or gladius upon which to base a classification, some strange relationships would emerge when compared with the modern classification based on such characters as tentacles, fins, a radulae, gills, liver-pancreas, eyes, suckers, etc.

A brief survey demonstrated this enigma by illustrating species grouped according to apparent relationships based on similar structure of shells or gladii and comparing the results with the currently accepted classification.

The shell has undergone an extreme modification in most Recent cephalopods to such an extent that it is hardly recognizable as a molluscan feature. Even within the class extensive variation in form and structure ranges from the coiled, chambered, external shell of *Nautilus*, the calcareous, finely septate cuttlebone of *Sepia*, the featherlike gladius or pen of some squids, the cartilaginous stylets of octopuses, to the entire absence of a pen in some species of each major Order.

The 16 basic groups revealed by this preliminary study indicate the broad diversity in structure of the cephalopod shell. The groups arranged by shell similarities only contained a mixture of actually unrelated species. For example, one group consisted of species from different suborders, while another contained species from different orders.

The shell of cephalopods, therefore, while of supreme importance in the systematics and phylogeny of fossil forms, is of more limited value in determining relationships of living species.

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SCAPHOPODS OF THE SOUTHWESTERN ATLANTIC OCEAN¹

Victor Scarabino*

A check list and the latitudinal and bathymetrical distribution of the scaphopods from Cape San Roque (Brazil) to the Antarctic Peninsula are presented, based on material of Argentinian, Uruguayan, Brazilian, North American, French, and British Institutions.

33 species were reported and placed as follows; in the family Dentaliidae in two genera: *Dentalium* with 20 and *Fustiaria* (4) and in the Siphonodentaliidae in four genera: *Cadulus* (6); *Entalina* (1); *Pulsellum* (3) and *Siphonodentalium* (1).

New records of species coming from both higher and lower latitudes are also reported. The study of the assemblages of forms from the North and South Western Atlantic confirm the preference of the group for temperature-warm to tropical regions.

The deepest record cited in the literature for living scaphopods from the southwestern Atlantic is 3475 m (*Dentalium amphialum* Watson 1879 "off Rio de la Plata"). New deep sea material that is under study will add more information.

¹ The final list will be published with Patrick M. Arnaud from the Marine Station of Endoume (Marseille, France).

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THE UNIONID MOLLUSKS RESTRICTED TO THE TENNESSEE AND CUMBERLAND RIVER SYSTEMS

David H. Stansbery*

A review of the unionid mollusks found only in the Cumberland and Tennessee River systems has resulted in a greater list than previously known and a theory of origin of this fauna.

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THE EFFECT OF "ONCE THROUGH" POWER PLANT COOLING OF FRESHWATER MUSSELS

James M. Stilwell,* M. Claire Matthews* and Duane E. Bell*

Growth rates have been determined for the dominant species of freshwater naiads collected in the vicinity of three fossil fuel electric power plants located on the Muskingum River in Ohio. The species composition and diversity of the naiad population in the area of one of the plants have been compared with data collected 10 years previously. Curves derived from shells collected upstream and downstream of the thermal outfalls of these plants were then compared. No significant differences in growth rates could be attributed to the increased temperatures found downstream of the plants.

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NOTES ON SOME NEPTUNEIDS

Robert R. Talmadge*

Although the circumboreal marine gastropods belonging to the genus *Neptunea* are, for the most part, neritic to bathyl in habit, a few localized populations have been found living in the lower subtidal levels. In some instances, this was attributed to breeding, storm-wave debris, or still-living snails discarded along with fisheries trash. However, most records of such intertidal populations are caused by still unknown reasons.

Several species of *Neptunea*, usually those inhabiting a geographical range of less than 1200 miles in linear extent, have little, if any, significant shell differences, either within a population or between populations. Other species exhibit the same shell characteristics within a population, but alter shell forms in other populations on distal portions of the range of the species. This is the basis for the biological unit, "Subspecies or Geographical Race". The variation trend may be gradual, usually noted in a species with a continuous distribution, or there may be major breaks in shell morphs, usually found in species with a discontinuous distribution. A third unit of neptuneids consists of populations which may have one or more shell morphs, repeated many times within the distributional area. The percentage of shells of the various forms varies between populations, creating a rather confusing situation, which only in part may be based upon geographical races. Anatomical comparisons are a must in this situation to verify if one or more species, especially sibling species, are present.

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AMU COMMITTEE AND BUSINESS REPORTS

REPORT OF AMU ANNUAL BUSINESS MEETING, AUGUST 7, 1974

The Annual Business Meeting of the AMU was called to order by President Harold D. Murray. A motion to approve the minutes of the 1973 Annual Business Meeting as published in the 1973 AMU *Bulletin* was approved.

President Murray summarized the reports of the Recording Secretary and Corresponding Secretary as submitted to the Executive Council August 5, 1974. The Convention approved the reports as summarized, and they are printed on the following pages.

Mrs. Myra Taylor, Treasurer, summarized the Treasurer's report for 1973. She noted that in the past page charges have been paid for by authors who are funded by a grant or an institution, but AMU pays for the charges if authors are not so funded. A motion to continue this policy with a clarification of the policy statement was approved. The Treasurer's and Auditors' reports for 1973 were approved and are printed on the following pages.

President Murray summarized the report of the chairman of each committee of the Council, giving the action of the Executive Council on August 5, 1974:

Publications Committee — It was announced that Mrs. Jeanne Whiteside had resigned her position as editor of the Newsletter to assume the chairmanship of the Conservation Committee. A statement of thanks was made for her efforts as Newsletter editor. The new editor for the Newsletter, Mrs. Dorothy Beetle, was announced. Dr. Arthur Clarke reported that he hoped to expedite publication of the *Bulletin* and that referees would soon be receiving copies of manuscripts. The report was accepted as summarized.

Membership Committee — This committee had prepared a new form for attracting new members to the AMU, and it was noted that some new members had been obtained using this form. The Council approved \$25.00 expenditure for costs accumulated by the chairman, Dr. Dorothea Franzen. The report was accepted as summarized.

Conservation Committee — The Council approved the request of the Conservation Committee to prepare a list of member experts to be compiled to assist major environmental groups in their works. Member experts would appear on the list only with their permission. The Council approved the establishment of an *ad hoc* committee of the Council to set the guide lines of the Conservation Committee. A request to the Council to have mail-out bulletins of committee activities was defeated, and the Awards Committee

was eliminated because of a lack of interest. The request of the Committee to involve the AMU in legal action on the Big Darby Creek, Ohio, Case was defeated by the Council. The report was accepted as summarized.

History and Archives Committee — The committee and the Council expressed its thanks to Mr. Dan Steger and Mrs. Gladys McCallum for slides donated to the Archives collection. A request was made by the chairman, Dr. William J. Clench, for more materials for the Archives. The report was accepted as summarized.

Nominating Committee — This committee presented the following slate of officers for 1974. The officers were unanimously approved by the Council on August 5:

President	Dr. Donald R. Moore
President-Elect	Dr. Dorothea Franzen
Vice-President	Dr. George M. Davis
Corresponding Secretary	Mr. Paul Jennewein
Councillors-at-Large	Dr. Carl Gugler
	Mrs. Constance Boone

There were no nominations from the floor and the slate was approved unanimously.

Annual Meeting Site Committee — The committee reported the receipt of an invitation to meet with the Western Society of Malacologists at San Diego State University, San Diego, California on June 22-26. The Council approved this site for the 1975 meetings and the report was approved by the Convention.

Budget Committee — This *ad hoc* committee was reported by the Treasurer, Mrs. Myra Taylor. She noted that there may be a \$350.00 anticipated deficit for 1975; however, the sale of *How to Study and Collect Shells* might offset this deficit, and there is over \$2,000.00 in a time certificate in case of emergency. Action to raise dues was deferred until 1975.

President Murray reported on other items approved by the Council on August 5. It was approved by the Council that the incorporation of the AMU would remain in California. The Council approved the immediate publication of the *How to Study and Collect Shells*, authorizing the Recording Secretary to sell the publication at 25% discount for the purchase of ten or more copies, and 40% discount for the purchase of 50 copies or more. The Council also reaffirmed its policy of not exchanging publications with other organizations. In further action, the Council clarified that there are only single life

memberships available and no joint life memberships.

Under new business before the Convention, it was moved, seconded, and approved that the AMU act as an intervening defendant in the case between the City of Columbus, plaintiff, and the Ohio Department of Natural Resources, defendant, in which case the city is attempting to prevent the state from designating Big Darby Creek as a state scenic river, and to declare the state scenic river law unconstitutional. In the event the court declares the AMU ineligible to be an intervenor, then the AMU will submit an *amicus curiae* brief in support of state scenic river designation for Big Darby Creek. Although the above motion was presented to the Council on August 5 and

defeated, it was presented as new business before the Convention. It was also moved, seconded, and approved that implementation of the above motion be started by the Conservation Committee without delay, that \$50.00 be allocated for lawyer's fees, and that an *ad hoc* committee be authorized to petition the Department of Fish and Wildlife to add four additional endangered species to the list.

The question of whether AMU should have a student section, with awards to encourage them, was assigned to the Membership Committee for study.

The President adjourned the meeting at 3:50 p.m.

Leona Grantier, Secretary *pro tem*

REPORT OF THE RECORDING SECRETARY

As of January 1, 1974, the membership of the AMU was 790, showing a net increase of 28 individuals and 2 clubs over the previous year. The following is a comparison by category with the previous two years:

	1/1/72	1/1/73	1/1/74
Individual	451	479	492
Individuals under Family Membership (2 or more people per membership)	190	208	216
Honorary Life Members	8	6	7
Clubs and Regional Organizations	45	47	49
Corresponding Members	23	20	26
TOTALS:	717	760	790

Included with the "individuals" were a number of institutions that were not segregated prior to 1973, when a separate dues category was approved. The following chart gives the full breakdown and membership status as of June.

	1/1/74	6/26/74
Institutions (U.S. and Canada)	28	32
Individuals	464	485
Individuals under Family Membership	216	228
Honorary Life Members	7	7
Clubs and Regional Organizations	49	50
Corresponding — Institutions	7	7
— Individuals*	19*	28*
	790	837

* Members with mailing addresses outside of U.S. and Canada segregated for convenience in mailing. Included regular members in Western Hemisphere, 5 at 1/1/74 and 14 at 6/26/74.

The increase in membership between 1/1/73 and 1/1/74 masks a large turnover of members. About 110 individuals, including family memberships, were dropped for non-payment of 1973 dues, yet new memberships more than made up for the loss. At least 50 and often over 75 members are lost each year, and only the increase in new members last year kept us from losing ground. We must keep trying to recruit new members to make up for the inevitable losses. Since most of those dropped are amateurs, it seems likely that they have simply lost interest, rather than that we have done something wrong.

Our members are very lax about notifying the AMU when they move. I can expect some 2% of any bulk mailing to be returned with an address correction, or sometimes with no forwarding address at all. If the Post Office gives us the new address, it costs us triple postage plus 10¢ to deliver the mail correctly, often after considerable delay. (There is postage out, back and out again, plus 10¢ service charge.) Sometimes the Post Office clerk does not forward OR return the mail — and we may lose a BULLETIN worth almost \$3. Even worse, we lose contact with a member and can't even bill him! PLEASE let us know before you move! ! Also, please let us know if you do not get a BULLETIN or a Newsletter within

two months of the expected time. Occasionally I have gotten back an undelivered publication with the original address label missing.

During the past year I was able to help a member in a special way, and I want to let everyone else know about this as a possible source of information. A professional from a northern state was going to study Gulf of Mexico mollusks last summer. He asked me if I could help with names of collectors in that area. My address label stickers are filed in Zipcode order, so I lent him the stickers for that geographical area. He chose the names he wanted and wrote to a number of amateurs in the area. He got excellent responses. His comment to me was that the amateurs were delighted that their collections could be of some real use to others — happy that they could be of assistance to a professional. I hope all researchers will keep this in mind in case of future need. We probably have a number of members who are not listed in AMERICAN MALACOLOGISTS, as our members are constantly changing, and constantly moving from place to place.

Respectfully submitted, Marian S. Hubbard,
Recording Secretary

REPORT OF THE CORRESPONDING SECRETARY

Letters asking for information or other help continued to arrive in batches at about the same rate as last year. Big spurts occurred before Christmas and in early spring. The average was running about a letter a day. About one in three letters asked for the booklet, HOW TO COLLECT SHELLS.

An item on the AMU in "Sea Secrets" supplemental leaflet of the International Oceanographic Foundation in Miami that goes to schools and libraries, prompted a number of inquiries to Marian S. Hubbard, whose address was listed. The item suggested writing the AMU for its list of 50 shell clubs or its publication, HOW TO COLLECT SHELLS. Mrs. Hubbard attempted to answer the first few, then passed the rest to the Corr. Secy.

Form letters continued to help in letting most inquirers receive prompt replies. Some required a little more information than could easily be placed on a form letter. About half the mail continued to come from youngsters who had read one or more of the books or guides on shells and wanted more specific information. A few asked for the baffling "more information" without any hint at what sort of information.

The Philippines, with their wealth of shells, were the source of most of the overseas inquiries, and virtually all were from prospective dealers who sought

information on going into business, lists of shells with values and possible customers. In most cases, they were referred to dealers who might help them.

Apart from the routine, the corresponding secretary sent a wire to the AMU's newest Honorary Life Member on the closing afternoon of 1973's Annual Meeting, then followed it up with a letter when he reached home. (Months later he learned Emery P. Chace's last name doesn't have an "s" as the address in the AMU BULLETIN for 1972 indicates.)

Letters of thanks were also written to various organizations and individuals and correspondence was caught up finally in September, despite temptations of fishing, shelling and sailing.

Late in September, letters were written to 14 editors of magazines and to officials of various organizations interested in the resolution on maintaining the existing fresh water barrier in the Panama Canal, which resolution was adopted June 27, 1973. The letter that went to editors is as follows:

The American Malacological Union, an 840-member organization interested in the scientific aspects of mollusks and their shells, recently went on record as opposing the Panama Canal Company's proposal for a brackish water canal across the Isthmus of Panama.

While the AMU recognizes the need for sufficient

water to facilitate the movement of ships through the canal, it views the pumping of sea water into the Gatun Lake environment as a potentially dangerous act, in that it would allow the mixing of Atlantic and Pacific organisms.

Such a saline canal, the organization feels, would form a barrier to the net north-south movement of terrestrial and fresh water creatures, as well as destroy the present animal populations in and immediately around Gatun Lake and the Canal.

The AMU considers the plan as being ecologically irresponsible and strongly urges the use of other alternatives available to the Panama Canal Company.

A similar but different letter went to individuals and officials interested in the program and project. Both the resolution and supporting data were duplicated so that recipients would have copies.

Letters were received from the following magazines or newsletters, indicating they were considering publishing the letters: BioScience, Natural History, Newsweek, Science, Sport Fishing Institute and Time.

Letters were also received from David S. Parker, Governor of the Canal Zone and President of the Panama Canal Company, and Juan Antonio Tack, Ministro de Relaciones Exteriores, Republica de Panama. Parker indicated his company was not committed to pumping sea water. He said he had

commissioned a scientific group to prepare an environmental impact statement on technical alternatives and would pass the AMU statement on to this committee. He said he was committed to both the letter and spirit of the Environmental Policy Act in this regard.

Tack's three-page letter was in Spanish and said in part: "Nos es muy grato llevar al conocimiento de ustedes nuestra decidida cooperación en mantenerlos debidamente informados sobre cualquier medida que se trate de implantar contraviniendo los principios de la inalterabilidad de las condiciones de equilibrio ecológico existente hoy en la vía acuática interoceánica emplazada en territorio panameño." This appeared to indicate that he is aware of the problem and appreciated the interest of the AMU.

As for the publication of the letter, the only newsletter in that list which the corresponding secretary receives regularly is the Sport Fishing Institute Bulletin. It didn't appear there. There's no information on its appearing elsewhere, although SCIENCE indicated a letter from Dr. Victor G. Springer of the Biological Society of Washington contained the information that the AMU had passed a similar resolution to the one passed by the Biological Society of Washington.

Respectfully submitted, Paul R. Jennewein, Corresponding Secretary.

REPORT OF THE TREASURER FOR FISCAL YEAR ENDING DECEMBER 31, 1973.

CHECK BOOK BALANCE, JANUARY 1, 1973

2761.93

RECEIPTS:

Memberships:	Regular	2589.92	
	Sustaining	50.00	
	Life	125.00	
	Corresponding	101.25	
	Clubs & Organizations	562.75	3428.92
Sales:	HOW TO COLLECT SHELLS	48.40	
	RARE & ENDANGERED SPECIES	19.75	
	Back issues - BULLETIN	100.70	188.85
Miscellaneous credits		55.97	55.97
Total Receipts from Activities:			3673.74

TOTAL CASH TO BE ACCOUNTED FOR:

6435.67

DISBURSEMENTS:

BULLETIN	2436.32
NEWSLETTERS	305.07
Archives	398.00
Conservation Committee	151.27
Printing	158.21
Postage	176.46
Office Expenses & Supplies	107.15
Annual Meeting Expenses	164.23
Filing Fee - State of California	5.00

Travel — 2 Secretaries + Treasurer	596.54	
Miscellaneous expenses	55.44	
Total Disbursements		4553.69
Check Book Balance, December 31, 1973		1881.98
TOTAL CASH TO BE ACCOUNTED FOR:		6435.67
Savings Acct # 8289670, Broadway Nat'l Bank		2177.70
Interest added to Savings # 8289670, balance,	90.33	2268.03
CERTIFICATE OF DEPOSIT, # 6659, Bdy Nat'l Bank		3000.00
Int. added, balance	22.85	3022.85

RECAPITULATION OF ASSETS, DECEMBER 31, 1973:

Cash in checking account, Broadway National Bank	1881.98
Treasurer's Petty Cash — Myra Taylor	25.00
Secretary's Petty Cash — Marian Hubbard	100.00
Savings Account # 8289670, Broadway National Bank	2268.03
CERTIFICATE OF DEPOSIT, # 6659, Broadway Nat'l Bank	3022.85
TOTAL ASSETS:	7297.86
ALLOCATED TO LIFE MEMBERSHIP FUND:	1595.88
A.M.U. NET WORTH — DECEMBER 31, 1973	5701.98
CHANGES IN CAPITAL ACCOUNT:	
A.M.U. CAPITAL ACCOUNT, JANUARY 1, 1973	6593.75
A.M.U. CAPITAL ACCOUNT, DECEMBER 31, 1973	5701.98
NET DECREASE IN ASSETS — 1973	\$ 891.77

Respectfully submitted,
Myra L. Taylor, Treasurer

AUDITED:

T.E. Pulley and Constance E. Boone
Betty Allen

DATE:

1 March, 1974
11 March, 1974

TREASURER'S NOTE: DECREASE IN NET ASSETS DUE TO SEVERAL FACTORS:

1. Expenditures for Archives Room and Conservation Committee
2. No receipts from 1973 A.M.U. meeting and no page charges from authors.

REPORT OF CONSERVATION COMMITTEE 1974 ANNUAL MEETING

The meeting, chaired by Mrs. Jeanne Whiteside in the absence of Mrs. Esse Merrill, was open to all; attendance was approximately 37.

The treasurer's report for 1973 showed a balance of \$48.73 (out of \$200 allocated to this committee) plus \$100 for two awards for conservation projects, for which no entries were submitted. The sum for awards is still available.

A third set of conservation kits has been made up and distributed.

During a discussion of what AMU can do in the conservation field, attention was called to a publication of the Izaak Walton League, "2002 Questions for the Endangered Coastal Zone." It was suggested that information be included in the Newsletter regarding what literature is presently available, avoiding duplication of the aforementioned, including locality data on polluted areas.

A U.S. mollusk census, similar to that being undertaken in Great Britain, was rejected.

After a discussion of what AMU can do in the conservation field, it was moved, seconded and approved that we compile a list of experts in mollusks, providing the list to major environmentalists, offering our aid and assistance in any way we can.

Regarding a policy on state shells (some feeling it would cause over-collecting, and some that it would work for protection), it was decided by vote that this be left to individual states.

The National Wildlife Federation is to put out seals of various species of wildlife, and it was agreed that AMU would advise the N.W.F. as to an appropriate selection of endangered mollusks to portray.

In response to a question about a list of endangered species, it was reported that so far the list contains 15 California land snails, 35 midwestern mussels and 10 crustaceans.

It was pointed out in regard to the role of the conservation committee and its effectiveness, that the total environment needs protection, not just specific mollusks, and that we should adhere to our Code of Ethics adopted in 1973. We were reminded, however that the U.S. Army Corps of Engineers demands specific names.

It was agreed that the committee's role is hampered by having only annual meetings. To counteract this time lag it was suggested regional chairmen could keep in touch with local action, that the newsletter be supplemented by two notices yearly, that regional chairmen be chosen to advise members in their area of activity affecting conservation, and that AMU could voice its feelings to Corps of Engineers and similar groups. It was also suggested that we lend our name to existing organizations. After a reading of the conservation policy formulated in 1973, it was moved, seconded and passed that the conservation committee issue a bulletin on a regular basis informing members of general areas of interest related to endangerment of habitat and that regional directors assist.

It was moved, seconded and passed that the conservation committee study and take to the membership in 90 days an opinion on the National Land Use Act in regard to whether or not to support this Act.

Leona Grantier, Secretary *pro tem*

(Continued from page 1)

The last session was convened by Carol Stein and after lunch the members gathered for the Annual Business Meeting in the Museum of Fine Arts.

On Wednesday at 6:00 p.m. members gathered at the Stonehaven Hotel for a reception, followed by the Annual banquet. The management of the Stonehaven honored those at the head table with champagne. The banquet address was given by Dr. Ruth Turner, and concerned her experience in the Deep Sea Research Vessel, "Alvin." Ruth's beautifully presented program was accompanied by color slides, and the audience genuinely enjoyed her interesting presentation. After introductions and acknowledgements, the Past Presidents were presented to the group, and the new Officers were introduced. The

final adjournment of the 1974 AMU meeting came and those who were leaving early the next morning bade farewell to friends until next year.

Some of us could not leave our friends so soon, however, so on Thursday morning approximately 40 persons journeyed in private cars to a drained canal near the Connecticut River. Within minutes most of the members were wading in shallow water collecting several species of unionids just below the locks of the canal. By noon we began to tire, and those on the field trip drifted back to the Stonehaven or started home.

Respectfully submitted, Myra Taylor, Treasurer

THE AMERICAN MALACOLOGICAL UNION, INC.

ACTIVE MEMBERS 1974

Membership List Revised January, 1975

- Abbott, Dr. R. Tucker, Delaware Museum of Natural History, Box 3937, Greenville, DE. 19807.
- Abbott, Mrs. Sue D., Suite D-1-A, R.D. 3, Box 250, Hockessin, DE. 19707.
- Abreu, Mrs. Vivian B., 2709 Dewey St., Tampa FL. 33607 (Sea life relationship to human race).
- Aguiar, Dr. Carlos G., Dept. of Biology, Univ. of Puerto Rico, Mayaguez, Puerto Rico 00708.
- Alarcon, Sr. Benito Fuenzalida, Correo, Isla de Pascua, Chile (Easter Island species).
- Albert, Mr. and Mrs. Ernest, 905 S. Bayshore, Safety Harbor, FL. 33572.
- Alexander, Robert C., 423 Warwick Rd., Wynnewood, PA. 19096.
- Allen, James E., 1108 Southampton Dr., Alexandria, LA. 71301 (Tertiary micro-mollusca).
- Allen, Dr. J. Frances, 7507 23rd Ave., Hyattsville, MD. 20783.
- Allen, Mrs. Lawrence K., Box 822, Port Isabel, TX. 78578 (*Murex*, *Pecten*, world marines; dealer).
- Allen, Miss Letha S., 187 Argyle St., Yarmouth, Nova Scotia, Canada B5A 3X2 (General).
- Anders, Kirk W., Shells of the Seas, Inc., P.O. Box 1418, Ft. Lauderdale, FL. 33302 (Volutidae, all rare shells).
- Anderson, Carleton Jay Jr., 56 Kettle Creek Rd., Weston, CT. 06880.
- Anderson, Gregory L., Pacific Marine Station, Dillon Beach, CA. 94929.
- Angstadt, Mrs. Earle K., 247 Penn St., Reading, P.A. 19602.
- Aslakson, Capt. and Mrs. Carl I., 5707 Wilson Lane, Bethesda, MD. 20034.
- Athearn, Mr. and Mrs. Herbert D., Museum of Fluviatile Mollusks, Rt. 5, Box 499, Cleveland, TN. 37311 (Freshwater mollusks).
- Athearn, Mrs. Roy C., 5105 N. Main St., Fall River, MA. 02720 (Land shells).
- Avellanet, Mrs. Helene, 115 Sunaire Terrace, Nokomis, FL. 33555.
- Avery, Mrs. R. Gail, Box 2557, Harbor, OR. 97415 (West American mollusks; exchange).
- Babrakzai, Mr. Noorullah, Dept. Biological Science, Univ. of Arizona, Tucson, AZ. 85721.
- Baeris, David A., 1233 Sweet Briar Rd., Madison WI. 53705 (Paleoecological interpretation through mollusks).
- Bagdon, Mr. and Mrs. Anthon, 440 Home Dr., Trafford, P.A. 15085.
- Baily, Dr. Joshua L. Jr., 4435 Ampudia St., San Diego, CA. 92103.
- Baker, Mrs. Horace B., 11 Chelton Rd., Havertown, PA. 19083.
- Baker, John, A., 147 Hedgegrove Ave., Satellite Beach, FL. 32937 (General).
- Baker, Nelson W., 69-990 Papaya Lane, Cathedral City, CA. 92234 (General).
- Balsam, Arthur, 1911 Fawn Dr., Philadelphia, PA. 19118.
- Banek, Thomas J., 466 Thatcher Rd., Springfield, PA. 19064 (Marine gastropods, taxonomy and ecology).
- Barker, C. Austin, 2 Hickory Dr., Rye, NY. 10580.
- Barlow, Dr. and Mrs. G. Barton, 5 Downey Dr., Tenafly, NJ. 07670.
- Barnett, George H., Koran Ave., M.D. # 23, Newburgh, NY. 12550.
- Barnett, Dr. Herbert C., Brazilian-American Biomedical Program, U.S. Consulate, Salvador (Bahia), APO New York, NY. 09676.
- Barton, Mrs. James, 20 Newfield Dr., Rochester, NY. 14616 (*Cypraea*; worldwide general, esp. Hawaiian).
- Bates, Dr. John M., 1900 Dexter Ave., Ann Arbor, MI. 48103.
- Battles, Harold J., 502 Pinon Dr., Morro Bay, CA. 93442 (Worldwide marine).
- Bauchman, Frank A., 1601 Big Bethel Rd., Hampton, VA. 23666 (Collecting).
- Bauer, Mr. and Mrs. Hugo C., 2126 45th St., Galveston, TX. 77550 (all Mollusca).
- Baum, Newman N., 83 Weaving Lane, Wantagh, L.I., NY. 11793.
- Baxa, Mrs. Dorothy, Box 177, Genesee Depot, WI. 53127.
- Bayne, Dr. C.J., Dept. of Zoology, Oregon State Univ., Corvallis, OR. 97331 (Gastropod physiology).
- Bazata, Kenneth R., Dept. of Life Sciences, Univ. of Nebraska, Lincoln, NE. 68508.
- Beetle, Ms. Dorothy E., 375 W. Galbraith Ave. # 42, Cincinnati, OH. 45215.
- Bennett, Dr. Terry M., Medical Advisor, U.S. Embassy, APO New York, NY. 09697 (Exchange).
- Bequaert, Dr. Joseph C., Dept. of Entomology, Univ. of Arizona, Tucson, AZ. 85717.
- Bereza, Daniel J., 825 N. 24th St., Philadelphia, PA. 19130 (Unionidae; Pleuroceridae).
- Berry, Dr. and Mrs. Elmer G., 13409 Accent Way, Germantown, MD. 20767.
- Berry, Dr. S. Stillman, 1145 W. Highland Ave., Redlands, CA. 92373.
- Bickel, David, Dept. Earth Sciences, Minot State College, Minot, ND. 58701 (Systematics and eco-

- logy of freshwater mollusks, esp. Pleurocerids).
- Bijur, Jerome M., 135 Seventh Ave. N., Naples, FL. 33940 (Buy, exchange Florida and Caribbean marine).
- Bippus, Mr. and Mrs. Alvin C., 2743 Sagamore Rd., Toledo, OH. 43606 (Marine gastropods).
- Blankenship, Shaw, Rt. # 2, Crab Orchard, KY. 40419 (Freshwater mussels).
- Blaser, James, 1846 Laurel Lane, Amherst, OH. 44001 (Florida mollusks; Ohio freshwater mollusks).
- Bleakney, Dr. J. Sherman, Dept. of Biology, Acadia Univ., Wolfville, Nova Scotia, Canada B0P 1X0 (Nudibranchs and sacoglossans; ecology, zoogeography, systematics).
- Bledsoe, William D., 352 Bon Hill Rd., Los Angeles, CA. 90049.
- Boone, Mr. and Mrs. Hollis Q., 3706 Rice Blvd., Houston, TX. 77005.
- Borror, Kathy Gail, 612 Northridge Rd., Columbus, OH. 43214.
- Boss, Dr. Kenneth J., Museum of Comparative Zoology, Harvard Univ., Cambridge, MA. 02138.
- Bottimer, L.J., Rt. 1, Box 50, Tow, TX. 78672 (Recent and fossil mollusks).
- Bowen, Philip R., 1004 Collins St., Hartsville, SC. 29550.
- Boyd, Dr. and Mrs. Eugene S., 6806 Gillis Rd., Victor, NY. 14564 (Phylum Mollusca - all aspects).
- Bradley, J. Chester, 604 Highland Rd., Ithaca, NY. 14850.
- Brady, Mr. and Mrs. E. Leo, P.O. Box 2515, Newburgh, NY. 12550 (Land snails).
- Branson, Dr. Branley A., P.O. Box 50, Eastern Kentucky Univ., Richmond KY. 40475.
- Bratcher, Mrs. Twila, 8121 Mulholland Terrace, Hollywood, CA. 90046.
- Bretsky, Mrs. Sara S., 91 Upper Sheep Pasture Rd., East Setauket, NY. 11733 (Ecology and evolution of Bivalvia, Tertiary and Recent).
- Bricker, Mrs. Minnie, Miss Donna Bricker, Walter Kurman, R.D. 3, Hanover, PA. 17331 (Conchs and Whelks).
- Brill, Mr. and Mrs. James A., 805 Johnson St., Terrell, TX. 75160.
- Britton, Joseph C., Dept. of Biology, Texas Christian Univ., Ft. Worth, TX. 76129.
- Brooks, Mrs. John C., 3050 Sunrise Blvd., Ft. Pierce, FL. 33450.
- Brown, Dr. and Mrs. Harvey E. Jr., 9455 S.W. 81st Ave., Miami, FL. 33156.
- Broyles, Dr. and Mrs. Ralph E., 5701 Fairfield Dr., Ft. Wayne, IN. 46807.
- Brunson, Dr. Royal Bruce, Univ. of Montana, Missoula, MT. 59801.
- Bryan, Edwin H. Jr., Bishop Museum, P.O. Box 6037, Honolulu, HI. 96818 (Pacific biogeography and bibliography).
- Buckley, George D., 164 Renfrew St., Arlington, MA. 02174.
- Buehler, William, 113 16th Ave. East, Ashland, WI. 54806 (Freshwater mollusks).
- Buerk, Minerva S., M.D., 331 Penn Rd., Wynnewood, PA. 19096 (Anatomy, histology).
- Bullis, Harvey R. Jr., 121 Island Dr., Key Biscayne, FL. 33149.
- Burch, Mrs. John Q., 1300 Mayfield Rd., Apt. 61-L, Seal Beach, CA. 90740.
- Burch, Dr. and Mrs. Thomas A., P.O. Box 309, Kailua, HI. 96734 (Dredging).
- Burger, Sybil B., 3700 Gen. Patch N.E., Albuquerque, NM. 87111 (Gulf of Mexico; land snails).
- Burgers, Dr. and Mrs. J.M., 4622 Knox Rd., Apt. 7, College Park, MD. 20740.
- Burghardt, Mr. and Mrs. Glenn, 14453 Nassau Rd., San Leandro, CA. 94577.
- Burke, Mr. and Mrs. Thomas D. Jr., 1820 S. Austin Blvd., Cicero, IL. 60650 (Marine mollusks of Eastern USA).
- Burky, Dr. Albert J., Dept. of Biology, Univ. of Dayton, Dayton, OH. 45409.
- Cahill, Michael, 1639 Madison St., Apt. # 4, Hollywood, FL. 33020 (Florida marine).
- Cameron, Hugh C., 3704 Edwards Rd., Cincinnati, OH. 45208 (Collecting).
- Campbell, Mrs. Minnie Lee, 3895 DuPont Circle, Jacksonville, FL. 32205 (General).
- Cañon, Sr. Jose R., Instituto de Fomento Pesquero, Casilla 1287, Santiago, Chile (Benthic ecology; South American Mollusca).
- Capo, Thomas R., 28 Windward Lane, Easthampton, NY. 11937 (Benthic ecology).
- Cardeza, R. Adm. and Mrs. Carlos M., P.O. Box 6746, Houston, TX. 77005; summer add. - 1718 Jewel Box Dr., Sanibel, FL. 33957 (Florida and Texas shells).
- Cardin, T/Sgt. Charles, 818 Camphor St., Vandenberg AFB, CA. 93437.
- Carlton, James T., Dept. of Geology, Univ. of California, Davis, CA. 95616 (Estuarine and brackish water mollusks).
- Carney, Dr. W. Patrick, Dept. of Experimental Parasitology, NMRI, NNMC, Bethesda, MD. 20014.
- Carr, Mrs. Jack C., 912 Broadway, Normal, IL. 61761 (Exchange worldwide marine).
- Castagna, Michael, Va. Institute of Marine Science, Wachapreague, VA. 23480 (Pelecypod larval behavior).
- Cate, Mr. and Mrs. Crawford N., 905 Strangler Fig Lane, Sanibel, FL. 33957 (*Mitra*, *Cypraea*; no exchanges).
- Cetnar, Dr. and Mrs. Eugene J., 4322 Bishop Rd., Detroit, MI. 48224.
- Chace, Emery P., 24205 Eshelman Ave., Lomita, CA. 90717.
- Chandler, Carl B. and Doris M., P.O. Box 621, Chatham, MA. 02633 (Cones, *Cypraea*).
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- Chroszczowski, Przemyslaw K., Aptdo 125, Maracay (Ar.), Venezuela (Planorbidae).

- Chichester, Lyle F., Dept. Biological Science, Central Conn. State College, New Britain, CT. 06050 (Ecology of terrestrial gastropods, biology of land slugs).
- Christensen, Carl C., Dept. of Biological Sciences, Univ. of Arizona, Tucson, AZ. 85721.
- Clark, John W. Jr., Texas Archeological Survey, Rt. 4, Box 189, Austin, TX. 78757 (Economic exploitation of mollusks by Indians).
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- Corgan, Dr. James X., Dept. Geography and Geology, Austin Peay State Univ., Clarksville, TN. 37040 (Microscopic gastropods).
- Courtney, Charles M., c/o Marco Applied Marine Ecology Station, North Barfield Dr., Marco Is., FL. 33937 (Aquatic ecologist/malacologist).
- Craig, Michael M., Dept. of Zoology, Univ. of Michigan, Ann Arbor, MI. 48104.
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- Curington, Roberta M., 6746 Ransome Dr., Baltimore, MD. 21207 (Marine gastropods).
- Cutler, Mr. and Mrs. Henry H., 105 Abbott Rd., Wellesley Hills, MA. 02181.
- Cvancara, Dr. Alan Milton, Dept. Geology, Univ. of N. Dakota, Grand Forks, ND. 58201 (Pleistocene and Holocene continental mollusks, early Tertiary continental and marine).
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- DuBar, Dr. and Mrs. Jules R., Geoscience Dept., Morehead State Univ., Morehead, KY. 40351 (Cenozoic and recent mollusks - ecology and paleoecology).
- Dundee, Dr. Dolores S., Dept. of Biological Science, Louisiana State Univ., New Orleans, LA. 70122 (Land mollusks, freshwater mussels).
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- Eddison, Dr. Grace G., District Three State Hospital, Paris, KY. 40361 (World marine).
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- Edwards, Lt. Col. Corinne E., USAF (Ret.), P.O. Box 691, Coconut Grove, FL. 33133 (Chitons; self-collected).
- Edwards, D. Craig, Dept. of Zoology, Morrill Science Center, Univ. of Massachusetts, Amherst, MA. 01002 (Population ecology and behavior of marine benthic molluscs).
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- Flansburg, Dr. Ronald R., 2910 Pomona Court, Brookfield, WI. 53005.
- Foehrenbach, Jack, 91 Elm St., Islip Manor, NY. 11751 (Marine ecology).
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- Franke, Norman W., 1651 Nash Ave., Pittsburgh, PA. 15235 (Self-collected marine).
- Fox, Mr. and Mrs. Arnold, 112 Rennard Place, Philadelphia, PA. 19116 (*Pecten*, *Spondylus*, *Murex*).
- Franz, Dr. David R., Biology Dept., Brooklyn College, Brooklyn, NY. 11210 (Ecology and physiology, marine mollusks, esp. Nudibranchs).
- Franzen, Dr. Dorothea, Illinois Wesleyan Univ., Bloomington, IL. 61701.
- Fraser, Stanley, R.R. 5, Smith Falls, Ont., Canada.
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- Fullington, Richard W., Dallas Museum of Natural History, P.O. Box 26193, Dallas, TX. 75226 (Land and freshwater gastropods of North America).
- Gad, Kathleen J., 8911 W. Burleigh, Milwaukee, WI. 53222.
- Gale, Dr. William F., Ichthyological Assoc. Inc., R.D. #1, Berwick, PA. 18603 (Sphaeriids).
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- Gilbert, Prof. and Mrs. William H., 11 West St., Waterville, ME. 04901 (Marine and freshwater bivalves — ecology, behavior, systematics; *Tellina*, *Macoma*).
- Gilmour, Dr. Thomas H.J., Dept. Biology, Univ. of Saskatchewan, Saskatoon, Sask., Canada S7N 0W0 (Anisomyarian bivalves).
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- Glazebrook, Mr. and Mrs. Samuel, P.O. Box 651, Marathon, FL. 33050.
- Glick, Dr. Robert N. 13500 E. 12 Mile Rd., Warren, MI. 48093 (Cowries, cones, olives).
- Goethel, Lt. Col. (Ret.) and Mrs. Louis N., 9402 Nona Kay Dr., San Antonio, TX. 78217 (*Cypraea* — buy and trade).
- Goodfriend, Glen A., Div. of Invertebrates, Field Museum of Natural History, Chicago, IL. 60605.
- Graf, Robert A., 3217 Maxim Dr., Fort Wayne, IN. 46805.
- Grantier, Mrs. Bruce J., 7 Tiverton Dr., Ottawa, Ont., Canada K2E 6L4 (Persian Gulf shells).
- Greenberg, Mrs. Janis, 22762 Pacific Coast Hwy., Malibu, CA. 90265 (Tidepool Gallery).
- Greenberg, Mrs. Ruth, 22762 Pacific Coast Hwy., Malibu, CA. 90265 (Tidepool Gallery).
- Gregg, Dr. Wendell O., 2546 Hill St., Huntington Park, CA. 90255.
- Grimm, F. Wayne, 356 Mayfield, Apt. 3, Vanier, Ont., Canada (Holarctic terrestrial mollusks).
- Groeneveld, Miss Mae, 1183 Terrace St., Muskegon, MI. 49442 (*Cypraea*, *Conus*).
- Guckert, Richard H., P.O. Box 185, Thomasville, GA. 31792. (Systematics of freshwater mussels; ecology; physiology of Nassariidae).
- Gudnason, Mrs. Harold, 105 Danefield Place, Moraga, CA. 94556.
- Gugler, Dr. Carl W., School of Life Sciences, Univ. of Nebraska, Lincoln, NE. 68508 (Terrestrial pulmonates).
- Gunter, Dr. Gordon, Gulf Coast Research Lab., Ocean Springs, MS. 39564 (Ostreidae).
- Gustave, Al, 3929 North Third St., Phoenix, AZ., 85012 (*Murex*, *Astraea*, *Latiaxis*).
- Haas, Dr. John W., 1653 Medical Arts Bldg., Minneapolis, MN. 55402 (Volutes, Pectens, *Spondylus*).
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- Harris, Mrs. E. Milton, 3237 Carlisle Rd., Birmingham, AL. 35213.
- Harris, Major Marion J. and Mrs. Bessie B. Harris, Rt. 6, Box 347 T, Jacksonville, FL. 32223.
- Harrison, Mrs. Francis F., One Beaver St., Cooperstown, NY. 13327.
- Harry, Dr. Harold W., 4612 Evergreen St., Bellaire, TX. 77401.

- Haven, Dr. Dexter S., 336 Lafayette Rd., Yorktown, VA. 23490. (*Mercenaria mercenaria*, *Mya arenaria*, *Crassostrea virginica*).
- Hecht, Mrs. Paul L., 3636 Mineola Dr., Sarasota, FL. 33579.
- Heck, Lt. Col. Ralph L., P.O. Box 16712, Temple Terrace, FL. 33617 (Gastropods, esp. *Conus*, *Cypraea*).
- Hedges, Mrs. Arlene, 404 North East St., Crown Point, IN. 46307.
- Henderson, Jerry G., 1729 N.W. Greenbrier Way, Seattle, WA. 98177.
- Hensley, Steven V., 2488 S. Fletcher Dr., Fernandina Beach, FL. 32034 (Ecology of freshwater Pelecypoda).
- Hepler, Neil M. and Laura E., 435 S. Federal Hwy., Deerfield Beach, FL. 33441 (Cephalopoda, *Conus*, Cypraeidae).
- Herr, Mr. and Mrs. Frank L. Sr., 7901 Dewitt Dr., RFD # 3, Baldwinville, NY. 13027.
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- Hickman, Carole S., Biology Dept., Swarthmore College, Swarthmore, PA. 19081 (Tertiary molluscan paleontology).
- Hickman, Mrs. Harriette L., 11015 First Ave., Stone Harbor, NJ. 08247 (Worldwide *Epitonium*).
- Hicks, Mrs. Edwin S., 1522 Palmwood Dr., Eau Gallie, FL. 32935 (Recent and fossil marine shells of Western Atlantic).
- Hill, Frederick C., Univ. of Louisville, Water Resources Lab., Belknap Campus, Louisville, KY. 40208.
- Hillman, Dr. Robert E., Battelle-Clapp Laboratories, Duxbury, MA. 02332 (Molluscan ecology and physiology).
- Hoagland, Ms. Elaine, Dept. of Mollusks, Museum of Comparative Zoology, Harvard Univ., Cambridge, MA. 02138 (Ecology and evolution of marine mollusks).
- Hohman, Betty Jean, 10 Ferris, Apt. 101, Highland Park, MI. 48203 (Cones, Volutes, Murices).
- Holiman, Mr. and Mrs. Wayne, Box 246, Edinburg, TX. 78539.
- Holle, Dr. Paul A., 131 Holman St., Shrewsbury, MA. 01545 (Salt marsh snails).
- Hollister, Dean S.C., 201 Hollister Hall, Cornell Univ., Ithaca, NY. 14850.
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- Hubbard, Mrs. Marian S., 3957 Marlow Court, Seaford, NY. 11783 (Littorinidae; all juvenile mollusks).
- Hubricht, Leslie, 4026 35th St., Meridian, MS. 39301 (U.S. land and freshwater).
- Hulswit, Mart, 680 West End Ave., New York, NY. 10025 (SCUBA).
- Hunkins, Mrs. Ruth E., 133 Brook to Bay, Englewood, FL. 33533 (Miniature shells; exchange).
- Hunter, Dr. R.D., Dept. of Biological Sciences, Oakland Univ., Rochester, MI. 48063 (Physiological ecology of freshwater pulmonates).
- Hurd, John C., Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL. 36830 (Systematics of Unionidae).
- Hyett, Dr. and Mrs. Marvin R., 2031 Locust St., Philadelphia, PA. 19103.
- Imlay, Dr. Marc J., Bureau of Sport Fisheries and Wildlife, Office of Endangered Species, Washington, DC. 20240.
- Ing, Mrs. May and Michael Ing, Box 1750, Mayaguez, Puerto Rico 00708 (Small and minute shells of West Indies).
- Ishikawa, Samuel, 551 Fifth Ave., New York, NY. 10017.
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- Jackson, Ralph W., Rt. # 1, Box 229, Cambridge, MD. 21613 (Exchange land shells).
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- Jacobson, Mrs. Ursula, 5618 E. Montecito, Phoenix, AZ. 85018 (Indo-Pacific, esp. cones and cowries; West Coast-Panamic).
- Janowsky, Robert and Dorothy, 946 Ralph Ave., Brooklyn, NY. 11236 (*Cypraea*, *Murex*, Volutes).
- Jenkinson, Mr. and Mrs. John J., 189 W. Lakeview Ave., Columbus, OH. 43202.
- Jenneweine, Mr. and Mrs. Paul R., Box 394, Wrightsville Beach, NC. 28480 (Raising mollusks in aquaria; writing and illustrating articles on shell collecting).
- Jensen, Russell H., Box 3937, Delaware Museum of Natural History, Greenville, DE. 19807 (Mollusks of Bermuda).
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- Johnstone, Mrs. Kathleen Yerger, 2209 River Forest Rd., Mobile, AL. 36605.
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- Keegan, Mrs. Barbara, c/o Catholic Relief Serv., Apartado 2617, Managua, Nicaragua, Central America (Caribbean and Pacific mollusks of Central America).
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- Kovach, Jack, Dept. of Geology, Muskingum College, New Concord, OH. 43762 (Ecology, shell composition, paleontology of non-marine).
- Kraemer, Dr. Louise R., Dept. of Zoology, Univ. of Arkansas, Fayetteville, AR. 72701 (Freshwater lamellibranchs).
- Krauter, Dr. John N., Virginia Institute of Marine Science, Wachapreague, VA. 23480 (Ecology, distribution and systematics of Scaphopoda; benthic infaunal of U.S. East Coast).
- Krauss, N.L.H., 2437 Parker Place, Honolulu, HI. 96822 (Carnivorous land snails; biology).
- Krieger, Kenneth A., P.O. Box 22721 Emory Univ., Atlanta, GA. 30322 (Ecology and systematics of Hydobiiidae and Pleuroceridae).
- Kuczynski, Mrs. Florence, 7400 N. 46th Ave., Box 406, St. Petersburg, FL. 33709 (Collect, exchange, photograph shells).
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- Lowry, Walter G. and Nelle H., 552 Old Lundy Rd., Macon, GA. 31204 (Collect N.C. marine, exchange).
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- Malone, Mrs. Elsie, 1017 Periwinkle Way, Box 54, Sanibel Island, FL. 33957 (Buy, sell, exchange world shells).
- Marsh, Mrs. Therese C., P.O. Box 22291, Ft. Lauderdale, FL. 33315 (S.E. Fla. marines; worldwide bivalves).
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- Marshall, Mrs. Thomas H., 2237 N.E. 175th St., Seattle, WA. 98155 (World shells; exchange).
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- Mattera, Albert and Mrs. Emily, 4501 Traymore St., Bethesda, MD. 20014 (*Murex*).
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- McAlester Prof. A. Lee, Peabody Museum, Yale Univ., Whitney Ave., New Haven, CT. 06520 (Bivalve evolution and ecology).
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Most scientific journals send manuscripts to qualified reviewers to assist authors in avoiding errors and in improving their papers. The AMU has now adopted a similar policy. The AMU Council constitutes our review board and all manuscripts except abstracts are sent to appropriate members of this review board (usually two) prior to acceptance for publication.

The AMU Bulletin has also adopted as its standard the Style Manual for Biological Journals published by the American Institute for Biological Sciences, Washington. All manuscripts accepted for publication become the property of the AMU and may be edited for style in accordance with this standard.

NOTICE

A new edition of the popular symposium HOW TO STUDY AND COLLECT SHELLS published by the American Malacological Union is now available. Copies can be bought from

Mr. Paul R. Jennewein, Corresponding Secretary
American Malacological Union
Box 394
Wrightsville Beach
North Carolina 28480

The price is \$2.50.

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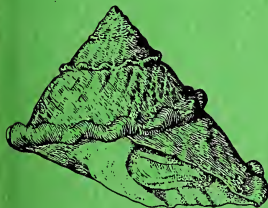
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JOINT MEETING of The

**Western Society
of Malacologists**

**The American
Malacological Union**



**Eighth
Annual Meeting**

**San Diego, California
22-26 June 1975**



**Forty First
Annual Meeting**

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Published January 30, 1976.

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The AMU Bulletin is the official annual publication of the American Malacological Union. It is published after each annual meeting. Communications about editorial matters should be sent to Dr. Dee Dundee, Editor, Dept. of Biological Sciences, Univ. of New Orleans, LA. 70122. Subscription orders from institutions, inquiries about missing issues and other circulation matters should be addressed to Mrs. Constance E. Boone, 3706 Rice Blvd., Houston, TX. 77005. Subscription rate for non-members of the AMU: \$10; back issues for members and affiliate institutions: write for rates and availability; AMU membership: \$7 plus \$1 per additional family member. Corresponding membership: (outside W. hemisphere) \$7 plus \$1.50 postage. Affiliate members (shell clubs, libraries, museums, etc.): \$10. Initiation or reinstatement fee for any member: \$1.50. Printing by the Hauser Press, Inc., New Orleans.

The Western Society of Malacologists is a West Coast-based national organization dedicated to the study of malacology. It normally issues an *Annual Report* based on its yearly meeting. This year a brief *Annual Report* is being issued containing the Society's essential business, the abstracts and papers from the joint meeting being contained in this *AMU Bulletin*. Distribution of the *WSM's Annual Report* is free to its regular and student members who are, at the time of issue, in good standing. Membership dues are \$5 for regular members and \$2 for students. Others of a regular member's family may join for an additional \$1; each family receives only one *Annual Report*. Correspondence regarding membership in the Western Society of Malacologists and orders for back copies of the *Annual Report* or other of the Society's publications should be addressed to the Treasurer, Mr. Merton J. Goldsmith, 1622 No. 20th St., Phoenix, Arizona 85006.

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**BULLETIN OF
THE AMERICAN
MALACOLOGICAL
UNION, Inc.**

for 1975

**JOINT MEETING
of The**

**Western Society
of Malacologists**

**The American
Malacological Union**



**Eighth
Annual Meeting**

**San Diego, California
22-26 June 1975**



**Forty First
Annual Meeting**

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Barbara Good - "Marine Mollusks of San Diego"

A.M. Frias-Martins- "Photographs of Micro-mollusca of the Azores"

James Lance & David K. Mulliner- "Outstanding nudibranch Photographs"

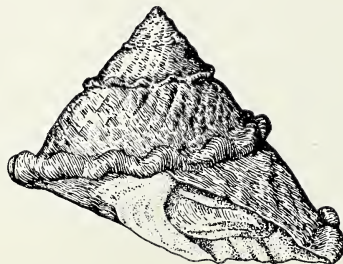
Bill and Lois Pitt- "Fossil Mollusks from Costa Rica"

Don and Jeanne Pisor- "Growth Series"

Leroy and Forrest Poorman- "Giants of their species"

Donald R. Shasky- "Tropical West American Cancellariidae"

Southwestern Malacological Society- "Learning to See"



JOINT MEETING

American Malacological Union, Inc. and Western Society of Malacologists
June 22-26, 1975 San Diego, California

Malacologists from East and West joined for this historic meeting in June, 1975, at San Diego State University, at San Diego, California. President George Radwin of WSM acted as host chairman for the event, and duties of directing events of the sessions were shared with AMU President Donald R. Moore. This meeting was dedicated to the memory of William Healey Dall, one of America's outstanding malacologists.

Opening day of the meeting on Sunday, June 22, found members of both organizations registering, greeting friends, gathering programs and other information about events and checking into Olmeca Dormitory. It was difficult to get every thing handled, dash over for lunch in the Cafeteria and then get to the afternoon session in Aztec Hall on time. Afternoon papers included reports on the legacy left for malacology by Dr. Dall, personal reminiscences of Dr. Dall by Dr. Wendell P. Woodring and reports on correspondence with Dr. Dall from Dr. Joshua L. Raily, Jr.

Sunday night everyone enjoyed the luau given by the San Diego Shell Club on the lawn outside Olmeca Dorm. Highlight of the evening was performance of the hula by Twila Bratcher.

Members were then invited to Aztec Hall for films on collecting and a delightful presentation by Dr. Robert Robertson, of photos of members taken through the years.

Some members of both organizations appropriated one of the study rooms of the dormitory and viewed slides of Nudibranchs. The tides were right and those who had permits planned dawn excursions.

Monday found members on time for the session after a hearty breakfast in the cafeteria. One of the delights for members was the association and meeting with malacologists such as E.P. Chace, Dr. Myra Keen, Dr. S. Stillman Berry (who is honorary life president of AMU), together with directors and curators of most of the major American museums. Monday afternoon's session was a symposium of Eastern Pacific-Western Atlantic faunal affinities, chaired by Dr. Emily H. Vokes.

The Conchological Club of Southern California catered a "chuckwagon style" dinner on the lawn outside the dormitory on Monday evening. The good food, homemade cakes, seconds available, made the evening a really pleasant one.

Executive board meetings were held by both WSM and AMU that evening while other members were entertained with a report on the

life and times of Dr. Stillman Berry. There was a report from one of AMU's new affiliate clubs, the Jersey Cape Shell Club, and an account of the 1974 AMU fresh water field trip at Springfield, Mass.

Meetings moved along on schedule on Tuesday. Everyone gathered for the photo at noon which was so much on schedule that AMU's incoming president, Dr. Dorothea Franzen, missed it as she hurried back from the cafeteria.

The evening's auction was well attended. There were so many, many shells available that the hour grew late and another session was set for another day. Bids were high with some very spirited ones for packets of minute shells and fossils.

The Council of Systematic Malacologists also met Tuesday night.

Wednesday's papers rolled along until 3:30 p.m. when the annual business meeting of AMU was called to order. Although there was important business to be handled, President Moore conducted the meeting smoothly and ended it in plenty of time to allow members to get ready for the festive banquet that evening.

There was an impressive number of past presidents of AMU and WSM introduced by President Moore. He thanked President Radwin for the success of the joint meeting and ended up with presenting a check for his own membership in WSM.

The banquet speaker, Sam Hinton of the University of California at San Diego, gave a delightful talk on "The Taxonomy of Common Names," completing his presentation with equally delightful combination of song and guitar.

The forty-first session of AMU was officially over. Papers scheduled for the next morning had been cancelled. There remained the WSM general business meeting. Those not attending this had time to visit in the dormitory lobby and view more thoroughly the exhibits set up there. Members also had had the opportunity during this meeting to go on field trips to Scripps, to collect Nudibranchs if they had permits and to view a reef if not, to visit mollusk and fossil departments of local institutions. Many also chose to visit the famous San Diego zoo, to dip into Mexico, a few to try hang gliding. The cool climate of San Diego, the really cold Pacific waters, proved surprising to many Eastern members. But all agreed the joint meeting, girls' dormitory and all, was fun and certainly worth the travel. Registration totalled 232.



PLATE 1. - MEMBERS AND GUESTS IN ATTENDANCE AT THE FORTY-FIRST ANNUAL MEETING

Identity of Malacologists in Photograph: 1 Unknown, 2 Unknown, 3 Unknown, 4 Norval Brewer, 5 William L. Woods, 6 Mae Dean Richard, 7 Brett Morrison, 8 Wendell O. Gregg, 9 Merton J. Goldsmith, 10 Blanche Brewer, 11 Carl C. Christensen, 12 William Minkler, 13 Jan Greenberg, 14 Hollis Q. Boone, 15 Gary L. Pace, 16 Joshua L. Bailly, 17 Bruce H. Fowler, 18 Hal Lewis, 19 Walter B. Miller, 20 Judith Christensen, 21 Wesley M. Farmer, 22 Louise Lewis, 23 Beth Brewer, 24 Joseph P.E. Morrison, 25 Chuck Courtney, 26 Jerry Harasewych, 27 Edgar J. Halley, 28 Ruth H. Fair, 29 Richard Reeder, 30 Russell H. Jensen, 31 Helen DuShane, 32 Roland Taylor, 33 Tim Chapman, 34 Harold Vokes, 35 James Carlton, 36 Jerry Landye, 37 Peter D'Eliscu, 38 H. Wallace Roberts, 39 Kay Taylor, 40 George Hemingway, 41 Glenn Long, 42 George M. Davis, 43 Charlotte Johnson, 44 Barry Roth, 45 Charles L. Powell, 46 Emily Vokes, 47 Vida Carmen Kenk, 48 Lucinda Draper, 49 Fred G. Hochberg, 50 Eugene V. Coan, 51 Elaine Hoagland-Davis, 52 Artie Metcalf, 53 James H. McLean, 54 Clyde F.E. Roper, 55 Clifton L. Martin, 56 Harold D. Murray, 57 Albert Taxson, 58 Ingrid Roper, 59 Hans Bertsch, 60 Adlai B. Wheel, Sr., 61 W.L. Pratt, 62 Elois Crum, 63 Harold A. Rehder, 64 Wendell P. Woodring, 65 Anna Palne, 66 Anne Taxson, 67 Lois C. Rehder, 68 Mary Rosewater, 69 Bertram C. Draper, 70 Suzanne Pratt, 71 Irene Wheel, 72 Joseph Rosewater, 73 S. Stillman Berry, 74 Louie Martinovich, 75 Rose A. Burch, 76 Rose D'Attilio, 77 Sally Bennett, 78 Roy Poorman, 79 Jo Ramsaran, 80 Anthony D'Attilio, 81 Jeanne S. Whiteside, 82 Ivan E. Thompson, 83

Also attending but not in photograph: [or among unidentified therein] R. Tucker Abbott, Noorullah Babrahzi, Nooshie Babrahzi, Tom Backman, Joe Bibbey, Mrs. William Bledsoe, Carla Bratcher, Ford Bratcher, Jack Breese, Joseph Britton, Pat Brophy, Kathy Cadien, Don Cadien, Barbara Chaney, Henry Chaney, Arthur Clarke, Phyllis Crane, Philip Crane, Suzanne Cummings, Mary D'Aiuto, John D'Aiuto, Greg Daly, Lillian B. Davenport, Richard Dilworth, Dorothea Franzen, Lois Goldsmith, Barbara Good, Frank E. Good, Ernie Haigh, George Hanselman, Sam Hinton, Mrs. Sam Hinton, Richard S. Houbbrick, Todd Hutchence, Ursula Jacobson, Albert Johnson, Nona Johnson, Carol Jones, June King, Christopher L. Kitting, Florence Kuczynski, Patrick LaFollette, Lauren Lewis, Olive Lewis, Steven

Costance Boone, 84 Bill Pitt, 85 Bernadine Hughes, 86 Myra Keen, 87 Joyce Gemmell, 88 Henry Bagdon, 89 Rhoda Webb, 90 Agnes Thompson, 91 Bill Gemmell, 92 George Radwin, 93 Lois Pitt, 94 John Webb, 95 Hyacinth B. Rowe, 96 Beatrice L. Burch, 97 William Bledsoe, 98 Marjorie Neiswanger, 99 Patricia Bagdon, 100 Esther Parodiz, 101 Carole Hertz, 102 Carol Skoglund, 103 Juan J. Parodiz, 104 Vera Schieler, 105 Lorrie Hudson, 106 Donald A. Moore, 107 Gale G. Sphon, 108 Roy L. Hudson, 109 Twila Bratcher, 110 Jean Cate, 111 Helen King, 112 Ruth Waters, 113 Billie Dilworth, 114 Forrest Poorman, 115 Virginia O. Maes, 116 Ruth Purdy, 117 Edith Abbott, 118 Myra Taylor, 119 Tom Rice, 120 Juliette Compitello, 121 Joyce Clover, 122 Viola Perrault, 123 David Bickel, 124 Margaret S. Cunningham, 125 Dee S. Dundee, 126 Ben Purdy, 127 Marian S. Hubbard, 128 Phillip W. Clover, 129 Elsie Marshall, 130 Norma Dexter, 131 Edwin Roworth, 132 H. Wayne Holiman, 133 Barbara Chaney, 134 Sallie Crittenden, 135 Paul Jennewein, 136 G. Alan Solem, 137 Wilma G. Young, 138 Veronica P. Johns, 139 William K. Emerson, 140 Richard M. Kurz, 141 Judy Woolsey, 142 William Old, Jr., 143 Dorothy Raehle, 144 Joseph Vagvolgyi, 145 Kirk Anders, 146 Ursula Shasky, 147 Unknown, 148 Paul O. Hughes, 149 Robert Robertson, 150 Judy Terry Smith, 151 Robert R. Talmadge, 152 Ed Petuch, 153 Don Shasky, 154 George Kennedy, 155 Clifford A. Martin, 156 Joseph DuShane, 157 Audrey Holiman, 158 Bayle Greenberg, 159 Crawford N. Cate (& Robaire), 160 Dave Mulliner, 161 E.P. Chace, 162 Ruth Greenberg.

Long, Emile A. Malek, Kathy Marshall, Gary McDonald, George Mendenhall, Nola Michel, David Montgomery, Cynthia Moore, Dorothy Morrison, Margaret Mulliner, Stephen Newslinger, James Nybakken, Bette Nybakken, Rich Peckham, Andrea Purdue, Mrs. George Radwin, Grace Louise Richard Carol Roberts Gordon Robillard, Peter Rodda, S. Helen Salama, Maria Salama, Martin Schuler, Bob Schoening, Eva Schroeder, Eunice Seay, Jim Seay, David Schomman, Evelyn Schumaker, David H. Stansbery, Lula Sietman, Katherine Stewart, Kate St. Jean, Thomas Waller, Gladys Weber, Isabelle Welch, Ruth White, M.E. Young, H.D. Young.

TRIBUTE TO WILLIAM HEALEY DALL

WILLIAM HEALEY DALL - THE LEGACY HE LEFT FOR MALACOLOGY

Joseph Rosewater

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WILLIAM HEALEY DALL-1845-1927.

Members of the Western Society of Malacologists and of the American Malacological Union, our officers and councils have seen fit to dedicate this joint meeting to William Healey Dall. If he were with us today I think he would approve because from what I have learned of him I know that he was a man capable of accepting his own greatness with humility. He would certainly enjoy the scientific papers which are to come and would, no doubt, comment on many of them constructively. To many of us Dall's immediate importance may seem to lie in his having been in charge of the mollusk collections of the Smithsonian Institution in Washington, D.C., for 47 years, from 1869-1915. But this is not the only reason for dedicating this meeting to Dall. His contributions to our science were immense in their number and

in breadth of coverage, spanning our country from coast to coast and from border to border, and beyond to encompass the world. This legacy he left is of great importance to members of both our organizations.

It is necessary to examine the life and contributions of this man to make more clear why we are honoring his memory and why the legacy he left for malacology is such a rich one. There have been a number of memoirs to Dall in which his life was described and his scientific accomplishments extolled. I have extracted many of the following details from a number of them, including Gates (1905); Merriam (1927, 1928); Bartsch, Rehder & Shields (1946); Herron (1948); Woodring (1958); Boss, Rosewater & Ruhoff (1968); and information in the Smithsonian Archives.

Dall was born in Boston, Massachusetts, on August 21, 1845. His father was a minister who probably inspired him in his intellectual pursuits. His mother was a radical reformer, a highly energetic and intelligent woman from whom he probably acquired much of his discipline and drive. Dall left school at 17, and due to the lack of funds and also a professed lack of interest in a formal higher education, he did not enroll at a university, but did study Zoology under Louis Agassiz and mollusks under A.A. Gould, whose classical book -- "Invertebrata of Massachusetts" (1841) awakened in Dall his life-long dedication to malacology. He became a student member of the Boston Society of Natural History during that time. He then accepted a job in Chicago between 1863-1865 where he worked for the Illinois Central Railroad. There he met Robert Kennicott of the Chicago Academy of Sciences who offered him a position as naturalist in the Scientific Corps of the Western Union International Telegraph Expedition to Explore Alaska for the purpose of finding an overland telegraph route through Alaska and Siberia to Europe. The party sailed from New York on March 21, 1865, via Nicaragua for San Francisco. At the May 1, 1865, meeting of The California Academy of Sciences mention of Dall's name was first made in its Proceedings. He was then 19 years old. As San Francisco was the base

of operations for the telegraph survey, Dall returned there several times a year. From a perusal of its Proceedings he participated in as many of the meetings of the Academy as possible, and presented a number of scientific papers on various aspects of West Coast malacology.

In these early years, Dall made numerous trips to Alaska during which he explored much of this unknown land, cataloging its ethnology, geology, and natural history. Thousands of specimens of mollusks and other animals were returned to the Smithsonian collections as Dall had an agreement to collect for the Institution.

In 1869, after returning from the Alaskan telegraph surveys and later work in charge of Coast and Geodetic Survey steamers charting the Alaskan coast, Dall took up residence at the Smithsonian in Washington. Although it is not realized by some, he was never an employee of the Smithsonian, but of the U.S. Geological Survey. His title as "Honorary Curator" was a just appellation as he was responsible for the arrangement of the collections and many of the curatorial methods that persist until the present day.

Dall produced over 1600 publications during his career. Many of these, it is true, were non-scientific in nature, but many also were significant contributions. Woodring (1958) listed 69 *major* works that Dall produced in his lifetime. Many of us would be grateful to have *one* of our papers placed in this category. His most important works are generally considered to be the publications arising from his explorations of Alaska, and the famous one on the paleontology of the southeastern United States, the "Contributions to the Tertiary Fauna of Florida." But many persons consider his descriptions of the molluscan fauna of the Caribbean area made in the "Blake Report," his classification of bivalves, or his survey of the northwest coast mollusks to be equally important.

Not counting suprageneric taxa, Dall described 5,427 species and genera of mollusks, worms, crustaceans, brachiopods, tunicates, and mammals; 5,302 were mollusks. As this joint meeting was to take place on the west coast of America, I thought it might be fitting to determine how much of this descriptive effort of Dall's was exerted here. A survey of the Boss, *et. al.* (1968) catalogue of Dall's names for West Coast entities yielded the following results. Roughly one third or 1,745 of his taxa bear eastern Pacific localities. The largest numbers of these species come from California (513), West Mexico (384), Alaska (362), western Central America (215), and the balance

from Canada (66), the other western states (139), and South America (66). Woodring (1958) pointed out that of the approximately 2,000 species and subspecies of mollusks known in 1921 from Alaska to southern California almost half (47 percent) were described by Dall. Only an unusual man could have done what he did.

What made Dall great? How could one man have accomplished so much in his lifetime? For one thing he lived 82 years, some 62 of which were spent in the pursuit of scientific knowledge and in the publication of the results of his research. In addition he lived at a time which has been called "The Descriptive Age of Malacology," when the catches from the great expeditions of the middle and late 19th Century were being studied and enumerated. The only other American worker known to have surpassed Dall in numbers of described taxa is Henry A. Pilsbry who introduced 5,680 names. Paul Bartsch ran third with a mere 3,278 according to Rehder, *in* Ruhoff & Rehder (1973). But there are other reasons for Dall's success. He appears to have acquired an encyclopedic knowledge in many areas other than malacology, including anthropology, vertebrate zoology, geography, paleontology, meteorology and other fields. He was a hard and energetic worker and must have had enormous powers of concentration. He is said to have been marvelously well organized (Woodring, 1958). Dall suggested the following as a work ethic: "Do the work next you, and do it with all your might. Nothing is too trifling to do well, and no knowledge attainable is useless" (Gates, 1905).

What should we do in response to the legacy Dall left us? Should we attempt to duplicate Dall's work by describing more taxa? Certainly there is describing to be done, but not to the extent that he did it. What it would appear that we need much more than that is a better understanding of the biology and relationships of our known malacological fauna and a synthesis of our knowledge, that is, an orderly grouping of the species and higher categories, rather than a further proliferation of individual taxa. The legacy that Dall and the others of his time gave us is a huge body of data with which to work and to study. It is our task and that of those who follow to try to analyze that data and build from it a more complete understanding of the Phylum Mollusca.

In conclusion, I think Dall may have explained his own success rather well in the following much-quoted statement, "The only lesson which may be said to be absolutely clear is, that naturalists are born, and not made; that the

sacred fire cannot be extinguished by poverty nor lighted from a college taper. That the men whose work is now classical, and whose devotion it is our privilege to honor, owed less to education in any sense than they did to self-denial, steadfastness, energy, a passion for seeking out the truth, and an innate love of nature. These are the qualities which enabled them to gather fruit of the tree of knowledge" (Dall, 1888).

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PERSONAL REMINISCENCES OF WILLIAM HEALEY DALL

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I first met William Healey Dall in 1915, while I was a student at Johns Hopkins University. From 1919 until his death in 1927 it was my good fortune to work across the hall from his spacious laboratory-library in the U.S. National Museum, now the U.S. National Museum of Natural History.

Though he made important contributions in many fields, he will be remembered chiefly for his work in malacology and Cenozoic molluscan paleontology. Many malacologists are not aware that from the time when he left the Coast Survey in 1884 until his retirement in 1925, he was a Paleontologist on the staff of the U.S. Geological Survey. From 1881 until his death he was Honorary Curator of Mollusks at the U.S. National Museum, and from 1869 to 1914 he was Curator in fact, if not in title.

He was a superb curator. He kept in immaculate condition his library and the collections under his supervision. A microscope was used only for anatomical work; for shells a hand lens was sufficient.

He was not a gregarious person. He arrived at his office on time and left on time. It was his custom to carry his lunch, which he ate by himself as he read. He was never hurried or harrassed, and I saw him really angry only once. I remember him as almost always writing and smoking a long-stemmed German pipe. He had a lucid, orderly, disciplined mind. It seemed that he instinctively organized his work in the most effective way.

CONTRIBUTED PAPERS PRESENTED AT JOINT MEETING

THE BEHAVIOR AND TENTACLE MORPHOLOGY OF PTERIOMORPHIAN BIVALVES: A MOTION-PICTURE STUDY

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Crawling, swimming, and the behavior and morphology of tentacles in the Pteriomorphian families Pteriidae, Limidae, Pectinidae, Spondylidae, and Anomiidae have been studied by means of close-up cinematography. This paper examines those aspects previously unknown or poorly understood and considers some general behavioral patterns and morphological features in an evolutionary context.

Methods and Materials

The species to be discussed are listed in Table 1, which also gives their size, reproductive maturity, and collecting locality in Bermuda, where the study was carried out in September, 1973. The molluscs were collected by SCUBA diving and transported, generally in aerated containers, to the Bermuda Biological Station, where they were placed in aquariums supplied with running sea water and substrates resembling in texture those of the natural habitats.

Mr. Kjell Sandved, professional photographer on the staff of the U.S. National Museum of Natural History, did the filming using Beaulieu 16mm motion-picture cameras equipped with a 90mm Macro-kilar lens or 40 and 60mm Zeiss Luminar macro lenses with specially devised semi-automatic diaphragms. The special aquariums were constructed of optically flat Corning glass or quarter-inch plexiglass kept free of condensation by an electric hair dryer. Lighting was by means of two 650 watt quartz-iodine floodlights with heat-filtering lenses. In some cases overnight time-lapse sequences were run using only a 200 watt Ascort strobe unit synchronized on timed demand with the rate of travel of the film. All photography was on color film (Kodak Ektachrome Commercial No. 7242 and 7252).

In the case of *Argopecten gibbus* and *Pecten ziczac*, individuals first observed and filmed in an aquarium were later transported to an area of clear, shallow water for underwater filming.

Bivalves capable of swimming generally do not swim unless provoked, either by a predator or an adverse environmental change. The principal stimulus used in this study, both in the aquarium and the underwater filming, was the starfish *Coscinasterias tenuispina* (Lamarck). This potential predator was found near the living sites of some of the bivalves, but was never found in the act of preying on them. Whether it is an actual predator on the species studied in Bermuda is unknown, but the vigorous reactions of the limids and pectinids to its approach suggest that it is.

OBSERVATIONS

Pteriidae

Pinctada imbricata, which normally lives attached by the byssus to a hard object or substrate (Waller, 1973), is capable of crawling after being forcibly detached (Stanley, 1970). A specimen 35mm in height managed to crawl, unobserved at night, up the glass side of an aquarium, where it secreted a new byssal attachment of nine threads radiating widely from the byssal notch. In this position the individual showed no escape reaction to the approach of a starfish, merely closing its valves when actually contacted by the tube feet.

The tentacles of *Pinctada* which can be observed when the shell is gaping during the normal feeding position are those located on the edges of the inner lobes of the mantle. A series of tentacles is also present on the middle lobe lying adjacent to the inner surface of the shell, but these were not extended or active and not observable on the film, even in the night time-elapse sequences. The inner-lobe tentacles showed no unusual motion during the approach of the starfish, and in fact they appeared to be incapable of any significant extension, retraction, or complex movement. Unlike the more advanced middle-lobe tentacles of *Lima* (Gilmour, 1967) or

Pecten, which are circular in cross-section and have complex muscular, hydrostatic, and neural systems, those of *Pinctada* are flattened, ramose structures that appear to be little more than extensions of the edge of the inner mantle lobe. The only type of movement observed consisted of groups of tentacles giving short quick flexures involving the adjacent inner lobe.

A young *Pteria colymbus* 8mm in length exhibited an extraordinary ability to lower and raise itself on a thread. The specimen, still attached to the branch of alcyonarian coral on which it was found, was placed in its natural position in the aquarium. During this transfer the little *Pteria* maintained its original living position, with the anterior side of its right valve pressed against the alcyonarian and its elongate, posterior wing directed upward.

When the floodlights in the laboratory were turned on, the specimen released its hold on the branch of coral and fell a distance of 15 or 20cm, spinning a very thin thread as it fell. It remained suspended on the thread with its antero-ventral margin upward for a short time and then, with valves agape, extended the tip of its foot to contact the thread, rotated into a position with anterior side upward, and began to climb up the thread (Fig. 1). In all bivalves, the foot is relatively larger in younger individuals than in mature ones, and *Pteria* is no exception. The foot extended to a length beyond the shell nearly equal to half the length of the shell itself. It probed and gyrated within a narrow radius about the thread, but in general seemed to align its basal groove with the thread during upward climbing. At times, however, the thread would pass the distal tip of the foot on the dorsal side, opposite to the grooved side. Presumably, at this growth stage the entire foot is ciliated, and the thread is being moved downward by ciliary activity as the bivalve climbs upward. Upward movement was smooth and gliding, with only an occasional abrupt pedal retraction.

At times the specimen lost its grip on the thread and fell freely, but each time it would either secrete or release more thread so that it would be suspended again before reaching the bottom. It appeared that these falls were marked on the thread by a blob of clear material that apparently was released at the precise moment that the fall occurred.

Finally, the *Pteria* managed to climb all the way back up to its original site of attachment. Upon reaching the branch of coral, it turned itself around to its original living position, so that the posterior wing, which was downward during

thread-climbing, pointed upward. This entire process was repeated several times in response to turning on the floodlights in a darkened laboratory.

We were unable to determine the nature of the thread. It was extremely thin and clear, except for a few blobs of clear material along its length, and could be either a byssal or a mucous thread. At one point in the film it can be seen that the thread emerges from a protuberance at the base of the foot at a point that seems to correspond to the position of the byssal duct. On this basis alone I am inclined to think that the thread is a byssus, possibly not hardened by contact with the more distal glands of the foot (assuming that the foot of young *Pteria* has multiple glands somewhat as in the foot of larval *Ostrea* described by Cranfield, 1973). No thread remained behind after the climb, and presumably the excess thread was moved by ciliary activity along the base of the foot and disposed of in the usual manner of pseudofaeces or excess mucus.

Limidae

Two individuals of *Lima lima* 21mm in height were found byssally attached side by side beneath the holdfast of a large gray finger sponge. They made no attempt to escape when the sponge was turned over, but in the aquarium these same individuals, lying free on the bottom after being forcibly detached, responded to the approach of a starfish. The initial response was to gape widely with the brilliant red pallial curtains and pale tentacles extending and undulating. When contact with the starfish occurred, each limid slid laterally with a single clap of its valves, turning away from the starfish as it slid. The same sequence of gape, rigid pallial curtains, tentacle extension and undulation, and a single short jet causing a lateral slide occurred repeatedly, but at no time did this species actually rise up off the bottom and swim freely. During the clapping movement, the tentacles are withdrawn nearly but not completely into the shell and the valves themselves do not close completely. If a specimen is traumatized, however, complete retraction of the tentacles and valve closure are possible.

Lima lima does not show any preference for lying on a particular valve and has no righting reaction such as that displayed by most pectinids. The foot was prominent in the individuals studied, and they showed a strong tendency to extend the foot and probe for an attachment site whenever they were adjacent to a hard object. Once an attachment was secured, pedal retraction would pull the flattened antero-dorsal region of the shell

against the substrate, with the plane of commissure approximately perpendicular to the attachment surface.

The tentacles of *Lima lima* are developed from the middle lobe of the mantle adjacent to the inner surface of the shell. They are of variable length, but the variation is continuous and there seems to be only one kind of tentacle present. All are circular in cross-section and greatly extendible, the largest located toward the interior of the shell and the shortest toward the exterior. The surface of each tentacle is papillose with a very vague annular arrangement of some of the papillae. Very distinct annuli, such as those described by Gilmour (1967) on the tentacles of *Lima hians*, are absent. Tiny, dark red eyes are present on each valve near the bases of the tentacles. The inner lobes of the mantle, or pallial curtains, have smooth margins without tentacles as in all limid species thus far investigated.

A young specimen of *Lima lima* 6mm in height climbed up the glass side of the aquarium with its relatively large foot, which was capable of extending to a length about equal to the diameter of the shell. During climbing, the plane of commissure was approximately perpendicular to the glass, the dorsal margin (hinge line) trailing, the ventral margin leading, and the flattened, straight anterior margin pressed against the glass. As is well known (Yonge, 1953), this position during crawling is unlike that of any other bivalve group, the foot being rotated 180° from its normal position.

The sequence of movements involved (1) extension of the foot, which probed from side to side before pressing down its tip; (2) a quick pedal retraction which pulled the shell up to the extended tip of the foot, accompanied by a simultaneous partial quick retraction of the tentacles and a clap of the valves; and (3) extension of the foot again. Precisely how the animal held on to the side of the aquarium while extending and probing with the foot was not observed. Possibly adhesion was by means of the heel of the foot, which may have remained affixed to the glass while the distal portion of the foot extended, or possibly it was by means of the tentacles which border the antero-dorsal, flattened margin of the shell. It did not appear that climbing was by means of the alternate spinning and release of byssal threads as is done by adult *Lima lima* (Stanley, 1970).

Tentacles of the young *Lima lima* are not annulated like those of the mature specimens. Only a very faint pink coloration is present on the pallial curtains and tentacles, allowing the dark

red eyes to stand out in contrast.

Four specimens of *Lima pellucida* ranging in height from 11 to 18mm were observed. This is a small species, reaching a maximum height of about 25mm, and to judge by the presence of brightly colored gonadal tissue the two largest specimens are mature.

Lima pellucida severs its byssal attachment and swims readily when its living site is disturbed. Like *Lima hians* (Gilmour, 1967), its tentacles are very extendible, reaching a length about equal to or slightly greater than the shell diameter, and bear distinct annuli. These rings presumably consist of mucous glands, because the tentacles, like those of *Lima hians*, are sticky and autotomize readily. Also like that species, *Lima pellucida* is unable to completely retract its tentacles.

The swimming behavior of the Bermudian specimens is also similar to that of the Eastern Atlantic species described by Gilmour (1967), but cinematography does not clearly reveal a rowing motion by the tentacles. Rather, they sweep backward at the precise moment that the valves close and the shell jets forward, so that it appears that they are behaving passively in the slipstream of water.

Individuals were capable of swimming above the bottom in flights approaching 50cm in length. More commonly, they would move by hopping along the bottom. When the dorsally projecting tentacles, which remain much more rigid than those elsewhere around the margin during swimming, would contact the bottom, a new valve adduction would jet the shell forward and upward again. During swimming in a straight path, water emerges from the shell through a single, nearly circular jet formed by the opposed pallial curtains in the postero-dorsal region. Movements are coordinated remarkably well and the animal is able to change its direction abruptly, even during a single valve adduction, by allowing additional jets of water to emerge elsewhere along the margin. Once the animal finds a crevice or manages to land next to an object on the bottom, it probes with an extended foot in preparation for a new site of byssal attachment. I did not observe any excavating movements by the tentacles such as those described in *Lima hians* by Gilmour (1967).

Unlike pectinids, which habitually lie with the right valve against the attachment surface, limids seem to be able to rest on either valve and to lack an overturning reaction. During resting phases between swimming movements, *Lima pellucida* is able to balance itself, probably by means of its

extended tentacles and gaping valves, so that its plane of commissure remains essentially vertical.

Pectinidae

Three species of scallops differing markedly in shell form (see illustrations in Warmke & Abbott, 1961) were filmed in the act of swimming in response to an approaching starfish. *Chlamys imbricata*, like most species currently assigned to the genus, has inequilateral valves with long anterior and short posterior auricles. The umbonal angle is narrow and shell height (perpendicular to hinge) generally exceeds shell length. Both valves are low in convexity, the left valve being somewhat flatter than the right. *Argopecten gibbus* is strongly biconvex, as its species name implies, but nearly equilateral. *Pecten ziczac* has a flat or even slightly concave upper (left) valve and a deeply convex lower valve, is equilateral, and has a broad umbonal angle. The living habits of these species have been described previously (Waller, 1973), and the swimming behavior of scallops is well known.

The most marked behavioral difference in swimming movements is that *Argopecten gibbus* jets water alternately between the antero-dorsal and postero-dorsal regions of its shell, so that it twists from side to side with each clap of the valves. In contrast, both the *Chlamys* and the *Pecten* jet water simultaneously from the two sides, although the latter may use the alternating method when first rising off the bottom. *Pecten ziczac* is the most graceful swimmer of the three, proceeding the furthest in a single flight and gliding further between claps, an outcome which is predicted on the basis of the aerodynamics of shell geometry (Stanley, 1970). Not predicted, however, is the low angle of attack assumed by *Pecten ziczac* in a long flight, during which its plane of commissure is essentially horizontal.

Pecten ziczac also exhibits a clear sequence of movements as it buries its convex lower valve in the sandy substrate. The scallop tilts itself so that its anterior margin is inclined toward the bottom. Then by clapping its valves it jets water from openings formed by the pallial curtains on both the anterior and posterior sides of the shell. The anterior jet, directed at the substrate, blows away the sand, whereas the posterior jet provides an opposing thrust to keep the scallop in position. This process occurs repeatedly while the scallop moves around the periphery of the growing depression. Finally, it slides into the depression and allows the sand suspended by additional clapping to settle on its flat upper valve. This is almost exactly the same pattern of behavior shown by *Pecten maximus* (Baird, 1958) and is

apparently a common trait among many pectinids which live unattached by a byssus (Waller, 1969).

Each of the three species has three sets of tentacles (Fig. 2), as do all members of the family Pectinidae thus far observed. Two sets are developed from the middle lobe of the mantle, one being a series of densely spaced short tentacles which border the edge of the shell, the other being a series of widely spaced highly extendible tentacles with bases somewhat more toward the interior. A third set, which is lacking in the Pectinacean families Propeamussiidae (Waller, 1972b), Spondylidae, and possibly the Plicatulidae (Watson, 1930) is developed along the edge of the inner lobe or pallial curtain. These three sets have been termed, respectively, fringing, exploratory, and guard tentacles (Waller, 1972a).

Time-lapse photography indicates that fringing tentacles undergo some extension and retraction but are relatively inactive compared to the exploratory tentacles, which can extend to a length nearly equal to half the diameter of the shell. All three types of tentacles have essentially smooth surfaces and lack the papilli or annuli found on the tentacles of limids. Instead, the pectinid tentacles are characteristically pigmented. Generally opaque white spots or bands form on the exploratory and fringing tentacles, whereas darker pigments may appear on the guard tentacles.

The guard tentacles are relatively short compared to the other types and when inactive have a fixed shape, curved so that their convex side is outward (Fig. 2). When the pallial curtains are nearly in contact with one another, the guard tentacles interfinger to form a coarse screen. When sedimentary particles are introduced, the tentacles, either individually or in groups, flick outward, seemingly to bat the particles out of the incurrent stream. During the intake of water preparatory to swimming, at which time the pallial curtains are very rigid, the guard tentacles fold outward and against the outer surface of their respective pallial curtains just before the valves clap. At no time did the guard tentacles vary their length, and it appeared that their action is primarily muscular rather than hydrostatic.

During swimming, the exploratory and fringing tentacles retract within the shell margins except for those which protrude at the ends of the auricles. These remain protruding and rather rigid, just as do the dorsal tentacles of the limids. *Spondylidae*

Both a large and small *Spondylus americanus* were studied by means of time-lapse photography. Spondylids have fringing and exploratory

tentacles and well-developed eyes like those of pectinids but lack guard tentacles, the edges of the pallial curtains being smooth. The exploratory tentacles appear less extendible and less active than those in the pectinids. *Spondylus* reacts to an approaching starfish simply by tightly closing its valves, reopening them slowly after the danger is past.

Anomiidae

The tentacle system of *Pododesmus rudis* is like that of *Spondylus*, but the anomiid lacks eyes. Upon the approach of a starfish, the individual gaped slightly, and when the tube feet of the starfish contacted the mantle of the bivalve, the valves moved in a gentle clapping or pumping action before closing.

CONCLUSIONS

The behavioral traits and tentacle morphologies of the bivalves herein reported appear to be remarkably conservative in an evolutionary sense. In terms of both features, the families studied fall readily into three groups: (1) the Pteriidae, (2) the Limidae, and (3) the Pectinidae, Spondylidae, and Anomiidae.

The tentacle systems of both *Pinctada* and *Pteria*, like those of all pteriid genera thus far studied, are basically simple and lack the functional specialization of the other groups. The behavior of these bivalves in the face of attack by a potential predator is also similar. They simply close their valves and hang on by means of their sturdy byssal attachment.

In contrast to the generalized tentacle systems and passive behavior of the Pteriidae, the tentacles of the Limidae are highly developed, as shown by Gilmour (1967); eyes are present; and limids exhibit a well-known swimming behavior in response to predator attack. In contrast to the Pectinacea, however, the tentacles of the Limidae are relatively undifferentiated, all exhibiting about the same degree of complexity and activity.

The Pectinacea possess highly differentiated tentacles, two types on the middle lobe of the mantle in the Spondylidae, Propeamussidae, and Pectinidae, and an additional set on the inner lobe of the mantle in the Pectinidae. Their mode of swimming is entirely different from that of the Limidae, the valves assuming a horizontal rather than a vertical position, there being two principal jets rather than one, and the tentacles being completely retracted into the shell during swimming except for those which protrude from the ends of the auricles. Unlike limids, which lie on either valve or attach with the plane of

commissure more or less vertical, the pectinids are distinctly and consistently pleurothetic with the right valve downward, and most exhibit a distinctive overturning reaction when upside down. The spondylids, although incapable of swimming because of their cemented habit, have an arrangement of middle-lobe tentacles and eyes like that of the pectinids and appear to deploy the tentacles in a similar fashion, both while agape and while clapping the valves. Recent observations by the author on a variety of Atlantic and Pacific pectinids and a species of Atlantic Propeamussidae indicate that the basic behavioral traits of these families are remarkably similar, even though anatomical and paleontological evidence suggests that they have had separate evolutionary histories for over 225 million years (Waller, 1972b).

In spite of a considerably different anatomical arrangement because of its prominent calcified byssus, the tentacle system and response of the anomiid *Pododesmus* is similar to that of the pectinids and spondylids.

The thread-climbing of young *Pteria* reported here is similar to byssal or mucous thread-climbing in other molluscan groups (Pelseeneer, 1935, p. 362) and is possibly a specialized trait that has evolved independently in many groups. It serves to keep the young from being swept away from their original attachment sites or prevents them from falling to the bottom, where environmental conditions for feeding and survival may be less favorable. In the case of young *Mytilus edulis*, the early dissoconch stages are capable of hanging from the surface film by short byssal threads (Nelson, 1928). Nelson supposed that this served to prolong the pelagic larval stage until contact could be made with a suitable object for permanent byssal attachment.

Verrill (1897) noted that "threads of adhesive mucus are formed by the foot glands of many land slugs and by certain marine species at the present time (e.g., *Litiopa bonbyx*, a small gastropod that attaches itself to floating sargassum in this way)." I was able to observe thread-climbing by the tiny Sargassum snail, *Litiopa melanostoma*, which had been shaken from its normal foothold on sargassum. Indeed the behavior is almost identical to that of the young *Pteria*, except that in the snail, mucus could be seen accumulating at the posterior end of the foot.

Verrill (1897) hypothesized an evolutionary relationship between mucous threads and byssal threads, suggesting that the earliest form of adhesion was temporary and perhaps aided by secretion of mucus from the surface of the foot.

Noting that "such a mode of adhesion to objects is common among planarians, small nemerteans, annelids, and the young forms of many groups at the present time," he supposed that "from such a primitive adhesive foot the transition to a larger foot with more specialized cells situated in a groove for the secretion of stronger byssus-like threads of mucus would have been easy."

The three groups formed on the basis of behavioral traits and tentacle specializations are also readily separable on the basis of shell microstructure, itself a highly conservative series of characters representing a genetically determined sequence of biochemical events during the ontogeny of the mantle epithelium (Taylor, Kennedy, & Hall, 1969). Virtually all extant Pteriacea (Group 1 above) have shells consisting of an outer layer of simple prismatic calcite and inner layers of nacreous aragonite. Group 2, the Limidae, have an outer calcitic layer which in some respects resembles the fibrillar calcite of the Mytilacea but which appears to be a unique microstructure found only in the Limacea (Waller, in preparation). It is not merely finely foliated calcite as reported by Taylor, Kennedy, & Hall (1969). Group 3 (Pectinidae, Spondyliidae, and Anomidae, as well as the Propeamussiidae, Plicatulidae, Dimyidae, and Ostreacea), is characterized by the presence of foliated calcite microstructure, which appears to be an evolutionary derivative of a particular type of simple prismatic calcite also present at least in the early ontogeny of these groups (Waller, in this volume). Aspects of shell microstructure are preservable in the fossil record, and these groups can be traced back into the Paleozoic era well beyond 250 million years.

ACKNOWLEDGMENTS

I thank Dr. S. Dillon Ripley, Secretary of the Smithsonian Institution, and the Smithsonian Research Foundation for funding this project; Mr. Kjell Sandved for his excellent photography; and Mr. Warren Blow for his resourceful assistance underwater and in the laboratory. Mrs. Ann Cohen alerted me to a thread-climbing performance of the sargassum snail; Dr. Edward Ayensu loaned a photo-optical analyzer; Dr. Klaus Reutzel provided a boat and motor; and Ms. Maureen Downey identified the starfish. Laboratory facilities were provided by the Bermuda Biological Station. The illustrations are the work of Mr. Larry Isham. Drs. Joseph Rosewater and Richard Houbrick read the manuscript.

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Table 1.

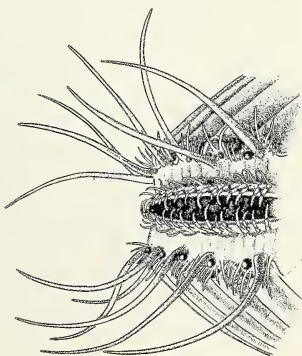
Bermuda specimens studied by means of closeup cinematography. Numbered specimens are in the collections of the Department of Invertebrate Zoology, U.S. National Museum of Natural History, Washington, D.C.

Species	USNM Number	Quantity	Length (L) or Height (H) in mm		Immature	Mature	Locality
<i>Pinctada imbricata</i> Röding, 1798	710705	1	35 (H)			X	North Lagoon adjacent to Bailey's Bay, 3 to 4 m.
<i>Pteria colymbus</i> (Röding, 1798	710706	1	8 (L)	X			Same.
<i>Lima lima</i> (Linne', 1758)	710707	2	21-23 (H)			X	Castle Harbor, 4.5 m.
<i>Lima lima</i> (Linne', 1758)	710717	1	6 (H)	X			North Rock, 5 meters.
<i>Lima pellucida</i> C.B. Adams, 1846	710708	4	12-18 (H)	X	X		Harrington Sound, 1 to 6 meters.
<i>Chlamys imbricata</i> (Gmelin, 1791)	710709	2	14-27 (H)	X	X		Castle Harbor, 2 to 4 meters.
<i>Argopecten gibbus</i> (Linne', 1758)	710710	17	26-55 (H)	X	X		Harrington Sound, 1 to 8 meters.
<i>Pecten ziczac</i> (Linne', 1758)	710711	4	43-70 (H)	X	X		Harrington Sound, 3.5 to 7 m.
<i>Spondylus americanus</i> Hermann, 1781	710712, 710718	2	21-60 (H)	X	X		"Bermuda"
<i>Pododesmus rudis</i> (Broderip, 1834)	710713	1				X	"Bermuda".

Fig. 1. Young *Pteria colymbus* 8 mm in length (USNM 710706) in act of climbing up a byssal or mucous thread.



Fig. 2. The tentacle system of *Argopecten gibbus* (USNM 710710), showing fringing and exploratory tentacles on the middle lobe (next to shell) and guard tentacles on the inner lobe of the mantle.



PRELIMINARY REVISION OF SUPRASPECIFIC TAXA IN THE
CERITHIINAE FLEMING, 1822 (Cerithiidae: Prosobranchia)

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Generic classification within the subfamily Cerithiinae Fleming, 1822 is a matter of controversy. Taxonomists working with cerithiids long have been plagued with problems resulting from an overabundance of proposed generic and subgeneric taxa. Because many proposed Cerithiinae groups cannot be defined sharply by any differential diagnoses, some groups, particularly within *Cerithium*, *sensu lato*, merge into one another.

The genera *Rhinoclavis* Swainson, 1840, and *Pseudovertagus* Vignal, 1904, are regarded both as generic and subgeneric taxa by various authors. These also have been synonymized with other cerithiid supraspecific taxa such as *Cerithium*, *Clava*, *Vertagus*, *Aluco*, and *Proclava*. Other proposed subgeneric groups are ranked by various authors in any number of combinations. The result is taxonomic chaos. For instance, a quick survey of shell manuals and literature reveals that the common Indo-Pacific cerithiid, *Rhinoclavis sinensis*, has been given 14 different generic and subgeneric assignments:

<i>Cerithium</i>	Hinton (1972)
<i>Cerithium</i> [<i>Aluco</i>]	Von Martens (1880)
<i>Cerithium</i> [<i>Vertagus</i>]	Tinker (1958)
<i>Cerithium</i> [<i>Rhinoclavis</i>]	Ladd (1972)
<i>Cerithium</i> [<i>Ochetoclava</i>]	Kira (1959)
<i>Cerithium</i> [<i>Clava</i>]	Thiele (1925)
<i>Rhinoclavis</i>	Cernohorsky (1972)
<i>Rhinoclavis</i> [<i>Ochetoclava</i>]	Kira (1959)
<i>Rhinoclavis</i> [<i>Rhinoclavis</i>]	Abbott (1950)
<i>Vertagus</i>	Dautzenberg & Bouge (1933)
<i>Clava</i>	Morris (1958)
<i>Ochetoclava</i>	Kuroda (1971)
<i>Clypeomors</i>	Kosuge (1969)
<i>Pseudovertagus</i>	Cotton (1964)

Taxonomic confusion with Cerithiids was mentioned by some earlier monographers. Both Brugulere (1792) and Kiener (1841) divided cerithiids into groups based on canal length and curvature, but Kiener noted difficulty in assigning species to various genera. Sowerby (1855) remarked that many authors described new genera without reviewing the complete array of cerithiid species critically. He lumped all of the species in his monograph under the genus *Cerithium* and went on to say, "...it is easy to take two or three species here, and form them into a genus under one name, and to take two or three there to make a genus under another name; but it is not easy to take every species and to place each in its appropriate genus. For if the species are placed in a line, it is almost impossible to mark the boundaries of the separate groups. I know an instance of a most accomplished conchologist attempting to arrange an extensive collection of Cerithiidae according to the modern style of numerous small genera, and the result was, of course, that he had a great many species which he did not know what to do with; and instances occurred in which specimens of the same species were placed apart in different genera. Endeavouring, therefore, to give a correct account of the species, and of course keeping those most alike, nearest to each other, I leave the task of forming generic groups to those who think them useful."

I believe Sowerby's last phrase bears much merit and attention. I am aware of 70 generic and subgeneric groups described under the broad concept of "*Cerithium*." The usefulness and value of these numerous subdivisions should be seriously questioned. This is more than just a matter of individual opinion. Although generic

allocations are subjective, they should be based on some criteria and have a certain utility. As Boss (1973) has recently remarked, the proliferation of supraspecific nomina is astonishing and obfuscates rather than elucidates relationships.

Similar supraspecific proliferation and confusion exists in other prosobranch groups such as cones (with 52 genera) and cowries (with 41 genera). A temporary solution is to relegate all related species to one broad generic group. For example, Kay (1960) proposed using *Cypraea* in place of numerous generic names assigned to species of Cypraeinae and Kohn (1963) assigned all species of Coninae to the genus *Conus*. However, I believe that this would not be expedient for the cerithiids and merely would generate more problems. Instead, I have chosen to reject groups that convey no more information than is already provided by good species and to keep only those that are clearly useful.

Mayr (1969) suggested two criteria to follow when considering need for new taxa above the species level: 1) an indication or clarification of a distinct phylogenetic relationship; 2) usefulness as an information retrieval system. Another criterion frequently used in science is "Occam's Razor": i.e., avoiding unnecessary multiplication of entities and choosing the simplest explanation for phenomena until proof of more complicated processes is obtained.

My evaluation of supraspecific Cerithiinae taxa employs the above criteria in considering conchological and anatomical characters. I also have used available ecological information. A thorough literature survey has reduced some taxa to synonymy. I have discarded groups proposed on the basis of what I regard as specific characters or equivocal supraspecific characters.

Many nomina have been proposed to accommodate fossil species and are difficult to evaluate; although I have included groups dating from the Cretaceous, most fossil nomina are in need of critical review beyond the scope of a short paper. I propose herein to deal mostly with Recent taxa.

In formulating a workable classification, it is important to note that cerithiids are polymorphic in shell size, color and sculpture. This is reflected at both generic and specific levels and has been the cause of undue splitting. I believe

supraspecific groups that have been created merely on the basis of a few equivocal sculptural characters are unreliable and invalid; moreover, some taxa have diagnostic characters that are based on specific rather than generic criteria. Nevertheless, new genera and species are proposed continually, sometimes almost recklessly. The most blatant example is the recent paper of Nordsieck (1974) in which two common Mediterranean species, *Cerithium vulgatum* and *C. rupestre* were divided into six genera comprising 56 species, six subspecies, and eight forms, surely a classic "*reductio ad absurdum*."

Radular characters, although of some value, should not be weighed too heavily. For example, two cerithiid species assigned to the genera *Proclava* and *Clavocerithium* have radulae that are virtually identical, yet these two are far-removed conchologically. Undoubtedly this radular similarity is due to convergence and suggests that cerithiid radulae are not conservative in characters and should not be overemphasized.

Protoconchs almost always are lacking, even in very juvenile specimens, and therefore are impractical taxonomic tools. When present, they are rather nondescript, and I find no merit in their use. Ornamentation of post-nuclear whorls is more reliable.

I believe apertural characters should be weighted most heavily in evaluating higher taxa. These have greatest stability and show little variation in Recent or fossil groups.

Although gross anatomical studies have been somewhat of a disappointment, I have been able to find anatomical characters separating the genera *Rhinoclavis* and *Cerithium*. I have studied living representatives of *Cerithium*, *Rhinoclavis*, *Theridium*, *Clypeomorus*, and *Semiurtagus* in the field, reviewed their gross anatomy, made observations on life histories, and studied their habitats and feeding. Anatomical studies also have been completed using preserved animals of the groups *Proclava*, *Clavocerithium*, *Ocheto-clava*, and *Pseudourtagus*. Scanning electron micrographs have been made of the radulae of all species in each group. Most of the Recent generic and subgeneric taxa I recognize may be traced back to the Pliocene. Using the above data and applying the criteria discussed, I suggest the phylogeny and tentative classification presented below:

See fig. 1 & 2

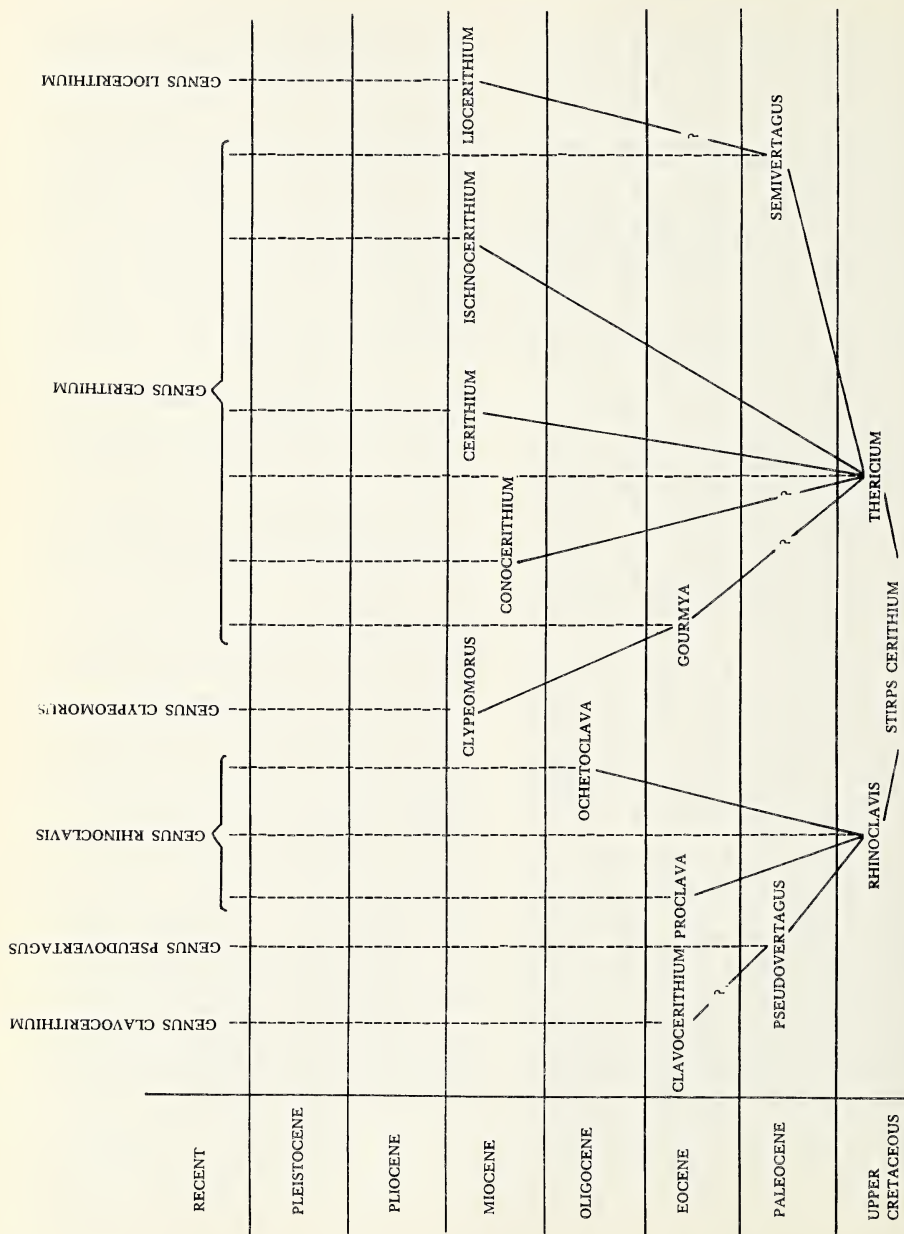


Fig. 1. Inferred phylogeny of supraspecific taxa in the Cerithiinae.

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SUBFAMILY CERITHIINAE:
 GENERA AND SUBGENERA

CERITHIUM

- C. [*Cerithium*] Bruguiere, 1789
- C. [*Gourmya*] Bayle in Fischer, 1884
- C. [*Thericium*] Rochebrune in Monterosato, 1890
- C. [*Conocerithium*] Sacco, 1895
- C. [*Semivertagus*] Cossmann, 1889
- C. [*Ischnocerithium*] Thiele, 1929
- *C. [*Perucerithium*] Olsson, 1929
- *C. [*Tiaracerithium*] Sacco, 1895
- *C. [*Chondrocerithium*] Monterosato in Cossmann, 1906
- *C. [*Chavanicerithium*] Ludbrook, 1957
- *C. [*Pseudoaluco*] Clark & Durham, 1946
- *C [*Hopkinsiana*] Olsson, 1929
- *C. [*Striovertagus*] Chavan, 1948

RHINOCLAVIS

- R. [*Rhinoclavis*] Swainson, 1840
- R. [*Ochetoclava*] Woodring, 1928
- R. [*Proclava*] Thiele, 1929
- ?*R. [*Dirocerithium*] Woodring & Stenzel 1958
- ?*R. [*Bellatara*] Mayer-Eymar, 1870

PSEUDOVERTAGUS

- P. [*Pseudovertagus*] Vignal, 1904
- *P. [*Cerithioclava*] Olsson & Harbison, 1953

CLYPEOMORUS JOUSSEAUME, 1888

CLAVOCERITHIUM

- C. [*Clavocerithium*] Cossmann, 1920
- *C. [*Indocerithium*] Chavan, 1952

LIOCERITHIUM TRYON, 1887

* Represents Fossil Taxa

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IS *MEIOCERAS* LIVING IN THE INDO-PACIFIC? (GASTROPODA: CAECIDAE)

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The genus *Meioceras* was established by Carpenter (1858) for a West Indian species with an unusual second stage. This stage was not curved on a single plane like most Caecidae, but evidently retained a vestige of the ancient spiral coiling of its ancestors. The result was widely open spiral looking something like a cow's horn. The adult shell, however, shows very little of the spiral twist and is slender to tumid in shape, glossy smooth, opaque, some shade of light brown, and sometimes with an intricate color pattern of dashes, dots or broad bands.

There are four species in the western Atlantic: *M. nitidum* Stimpson, 1851; *M. cornucopiae* Carpenter, 1858; *M. tumidissimum* Folin, 1869; and *M. cubitatum* Folin, 1968. Only *M. nitidum* has the second stage shaped like a cow's horn. There are many available names, mostly synonyms of *M. nitidum*. There does not seem to be any species of *Meioceras* in the eastern Pacific.

Three of the tropical Atlantic species are extremely abundant: *M. nitidum* in shallow, inshore locations, *M. cornucopiae* around coral reefs, and *M. cubitatum* in deeper water on the continental shelf (Moore, 1973, 1975). They are still poorly known because of the confusing number of synonyms and the small number of studies on micromolluscs in general.

Several species have been described from the Indo-Pacific. The Marquis de Folin in 1881 in two different papers described *M. sandwichensis* from Hawaii and *M. elongatum* from Hong Kong. A single broken specimen from Iraq was described as "*Meioceras* sp. nov." by Eames & Wilkins, 1957, but it has not been named since. Kisch (1959) reported three specimens of *M. carpenteri* Folin from Mer de Chine. Habe (1963) described *M. kajiyamai* from the Amami Islands, and referred *Caecum legumen* Hedley, 1899 to *Meioceras*.

At first glance, it appears that the genus is well established in the Indo-Pacific. A careful survey of the species, however, shows a different picture. *Meioceras* is very close to *Fartulum* Carpenter, 1857, and probably would not have been created if Carpenter had not found the striking second stage of *M. nitidum*. Species of *Fartulum* are very similar in size and shape to *Meioceras*, but lack color and color patterns. So,

M. sandwichensis, *M. kajiyamai*, and *M. legumen* should all be referred to *Fartulum* since they lack color. *M. carpenteri*, from "Mer de Chine," is clearly *Meioceras*, but the three specimens are *M. nitidum*, probably mislabeled as to locality.

This leaves *M. elongatum* Folin. The type specimens in the Folin collection are mature, but in poor condition. They look much like *Meioceras*; however, they also resemble another gastropod genus named *Parastrophia* Folin, 1869. The type species of this genus, *P. cornucopiae* (Folin, 1869), was described from Hong Kong. Folin's drawing of *P. cornucopiae* was extremely fanciful, and no one seems to have recognized the species since. Type material of both species is very poor, except for one specimen of *P. cornucopiae*. It is immature, but does retain the protoconch which is very distinctive and different from that in other gastropods. *Spirolidium sumatranum* Theile, 1925, is evidently a fine, mature specimen of *P. cornucopiae*. *Parastrophia* has been put in the Family Ciliceratidae by Iredale & Laserson (1957). The elongate Ciliceratids (some are secondarily recoiled) differ from the Caecidae in that the older portions of the shell are not shed periodically. Instead, the protoconch usually wears away. The mollusk counteracts this erosion by infilling the apical end of the shell with calcareous material. This varies in extent from species to species and individual to individual. The result is that a *Parastrophia* that has been long dead before being collected can look very much like a member of the Caecidae. Iredale & Laserson (1957) established two subfamilies of Ciliceratidae based on whether or not the coiled portion of the protoconch is retained. The chief characteristic of the Pedumicrininae is that the coiled portion of the protoconch is retained. In any one lot of *Parastrophia* (*Pedumicra* Iredale & Laserson is a synonym) the adults may or may not have lost a portion of the protoconch. The other subfamily, the Watsoniinae, has a protoconch in which the posterior part is always lost. This subfamily, as constituted by Iredale & Laserson, consisted of two genera, *Watsonia* Folin 1879 and *Gladioceras* Iredale & Laserson, 1957, with a single species in each. However, they did not recognize that their new genus and species, *Gladioceras armorum*, was identical with *Watsonia elegans*

Folin 1879. Hence this would leave *Watsoniinae* with a single species. As I have already indicated (Moore, 1967), *Watsonia* is actually little different from *Parastrophia*, and *Watsoniinae* should be suppressed in favor of *Pedumicrininae*.

Iredale & Laserson suggested that *Meioceras* was related to *Pedumicra* [= *Parastrophia*] and should be transferred from the *Caecidae* to the *Ctiloceratidae*. This theory cannot hold since *Meioceras* has the typical growth form of the *Caecidae*; as growth continues, first the protoconch and early part of the teleoconch is discarded; then, when nearing maturity, another length of teleoconch is dropped off. A septum is constructed to close off the posterior end of the shell each time. There can be no doubt that *Meioceras* is a typical member of the *Caecidae*.

Meioceras, then, may live in the Indo-Pacific, but it appears that all of the species from this region so far referred to the genus should be placed in the caecid genus *Fartulum* or in the *Ctiloceratidae*.

ACKNOWLEDGEMENTS

I take pleasure in thanking James Behensky for the bottom sample from Kealakekua Bay, Hawaii, in which I found the specimen of *Fartulum sandwichensis*. Thanks are due others who have provided Pacific material: Harvey Bullis, Dr. Richard Houbbrick, Dr. Thomas Borkowski, and John F. Meeder. This work was supported in part by NSF Ship Funding Grant GD-31576 and a number of other NSF grants; also, the American Chemical Society Petroleum Research Fund Grant No. 5063-AC2.

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THE PELAGIC OCTOPOD *OCYTHOE TUBERCULATA* RAFINESQUE, 1814

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A large octopod from southern Australia was sent to the National Museum of Natural History (NMNH) by Brian Smith, National Museum of Victoria, Melbourne, Australia, for identification. The specimen was a large female of the pelagic octopod *Ocythoe tuberculata* Rafinesque, 1814. Because this species is uncommon in collections, this fine specimen stimulated a search of the literature to determine the previously reported specimens and their distribution. The South Australian specimen is the first recorded capture of *O. tuberculata* from the waters of Australia. Furthermore, the species previously has not been reported from the entire central Pacific or the Indian Oceans. This paper records major extensions in range that verify a world-wide distribution, and it adds new information concerning certain aspects of the biology of *O. tuberculata*.

HISTORICAL REVIEW

The original description of *Ocythoe tuberculata* by Rafinesque (1814) was very short and carried no illustrations. The translation from the French follows:

"XVII G. *Ocythoe* Eight arms, the upper two winged towards the inside, with inner suckers pedunculate, joined by the lateral wings, no membrane at the base of the arms.

73. *Ocythoe tuberculata*. Ventral side tuberculate, dorsum smooth, arms [as] long as the body, keeled on the outer side, with two rows of suckers, eight suckers around the mouth."

Rafinesque's only other mention of the species appeared in 1840 in an obscure paper that comprised the first number in a proposed series of ten booklets entitled "Amenities of Nature"; each number was to be extensively illustrated. Unfortunately, Rafinesque died in 1840, and neither the remaining nine numbers nor any of the 10 supplements of illustrations was published. The article added valuable information to the initial meager description of *O. tuberculata*, and it clarified the misconception of contemporary biologists that *O. tuberculata* (or *Todarus*) was the animal that lived

in the *Argonauta* shell. Rafinesque's comments on *Ocythoe* are quoted here because the 1840 work is not readily available and largely has been overlooked resulting in misinterpretations by some subsequent workers who had not seen it. (See also Binney & Tryon, 1864).

"12. On the 3 Genera of Cephalopodes, *Ocythoe*, *Todarus* and *Anisoctus*.

"My G. *Ocythoe* altho' adopted by Leach and others, is yet a problematical animal for many, and I find even in late Journals discussions on its being or not the animal of the *Argonauta* shell - it would be wiser to ask me (the original discoverer) for my opinion or experience - I once wrote to Leach about it, but it was during his sickness, and I believe he omitted to publish my remarks, which were at variance with his. It is time therefore to settle this question, or rather throw new doubts on it perhaps; my recollections of my *Ocythoe* are quite vivid as a very remarkable animal.

"I omitted in my short account of the Genus (in my precis of 1814) to state the size of this animal, and thence have originated many wrong surmises. I did not state that it was the animal of the *Argonauta* since I never dreamt of such a thing, knowing the *Todarus* as the animal often found in it, (in Sicily,) while the *Ocythoe* never could dwell in it, being larger than a man's head, and weighing 15 pounds.

"Such was my *Ocythoe tuberculata* type of the genus and certainly not the same as that of Leach: this animal was brought to me alive in 1811 as a rare kind of *Octopus*, it was ferocious endeavoring to bite and wound the holder, although out of water for one hour: it changed color like a *Chameleon* from white to red in its angry and dying moments. It was killed as usual with the *Octopus* by turning its head [= mantle], a process well known to the Fishermen of the Mediterranean: else they will live long out of the water and are

dangerous till dead. I did eat this *Ocythoe* which afforded a meal for many, and it was as good as usual with the *Octopus*. The Fishermen never told me that it dwelt in the *Argonauta*, while all deemed their *Todar* the animal of it, calling the shell and animal by the same name, while the *Ocythoe* was called *Pulpu*.

"I do therefore aver that my *Ocythoe* is not the animal of the *Argonauta*, and could never be, by its size and thick spherical body, unfit even to enter it."

Rafinesque leaves little doubt that he ate the type-specimen! Robson (1932), citing Isnard (1922), erroneously stated that the type-specimen originally was in Orbigny's collection, but Isnard actually referred to the deposition of Verany's types. We can deduce that the type was a female

because it was "...larger than a man's head and (weighed) 15 pounds." Males of *Ocythoe* are known to be small, and probably do not exceed about 30 mm in mantle length (ML).

A summary of the verifiable records of specimens of *O. tuberculata* is presented in Table 1. Jatta (1896) and Naef (1923 a) gave extensive synonymies, although both omitted reference to Rafinesque's obscure 1840 paper. A great deal of nomenclatorial turmoil, only partly reflected in Table 1, accompanied *O. tuberculata* for three-quarters of a century, until Jatta (1896) was able to stabilize the uncertainty. Robson (1932) reviewed the literature but gave little specific data about the specimens he had, so their sizes and localities cannot be verified. The measurements of length listed in Table 1 are those given by the original authors or deduced from the discussions or from illustrations.

Table 1. A summary of the records of *Ocythoe tuberculata*.

Author, date: page	Species Name	No.	Sex	Size*(mm)	Location	Remarks
Rafinesque, 1814:29	<i>Ocythoe tuberculata</i>	1	♀	—	Med.	Type; no longer extant
Verany, 1851:37	<i>Octopus catenulatus</i>	1	♀	280 ML	Med.	Plate 12
Verany, 1851:34	<i>Octopus carena</i>	1	♂	30 DML	Med.	Plate 14, figures 2,3
Verany, 1851:126	<i>Hectocotylus octopodis</i>	1	♂	—	Med.	Plate 41
Verrill, 1880:293	<i>Parasira catenulata</i>	1	♀	51 ML	NW Atl.	Also, Verrill, 1882:362, Plate 33
Ortmann, 1888:642	<i>Tremoctopus dodereleini</i>	1	♀	200 VML	NW Pac.	Tokyo Bay, Japan, Plate 20
Jatta, 1896:198	<i>Ocythoe tuberculata</i>	1	♂	30 ML	Med.	Gulf of Naples, Plates 6,7,19
Jatta, 1896:198	<i>Ocythoe tuberculata</i>	1	♀	100 ML	Med.	Gulf of Naples, Plates 6,7,19
Joubin, 1900:26	<i>Ocythoe tuberculata</i>	3	♀	?-200 ML	Med.	Stomach of <i>Grampas griseus</i>
Wulker, 1910:4	<i>Ocythoe tuberculata</i>	3	♀	?-60 ML	NW Pac.	Sagami, Japan. Plate 1
Berry, 1916:3	<i>Ocythoe tuberculata</i>	1	♀	160 DML	NE Pac.	Southern California
Degner, 1925:81	<i>Ocythoe tuberculata</i>	1	♂	20 ML	Med.	R/V THOR
Sasaki, 1929:26	<i>Ocythoe tuberculata</i>	2	♂	18-21 VML	NW Pac.	Sagami, Japan. Plates 3,8
Sasaki, 1929:26	<i>Ocythoe tuberculata</i>	5	♀	70-160 VML	NW Pac.	Sagami, Japan. Plates 3,8
Bouxin & Legendre, 1936:30	<i>Ocythoe tuberculata</i>	1	—	35 BL	NE Atl.	Bay of Biscay
Joubin, 1937:38	<i>Ocythoe tuberculata</i>	7	♂	8-30 TL	N Atl.	R/V DANA. Figures 36,37
Joubin, 1937:38	<i>Ocythoe tuberculata</i>	7	♀	8-120 TL	N Atl.	R/V DANA, Figures 36,37
Berry, 1955:177	<i>Ocythoe tuberculata</i>	9	♀	16-163 ML	NE Pac.	Southern California. Figure 1
Rees & Maul, 1956:274	<i>Ocythoe tuberculata</i>	6	♀	12-190 DML	N Pac.	Stomach of <i>Alepisaurus borealis</i> Madeira Islands. Stomach of <i>Alepisaurus ferox</i>
Torchio, 1965:270	<i>Ocythoe tuberculata</i>	2	♀	155-175 DML	Med.	Figure 4
Voss, 1967:86	<i>Ocythoe tuberculata</i>	1	♀	21 ML	SE Atl.	South Africa
Hardwich, 1969:68	<i>Ocythoe tuberculata</i>	1	♂	16 DML	NE Pac.	Southern California. In salp
Young, 1972:92	<i>Ocythoe tuberculata</i>	1	♂	14 ML	NE Pac.	Southern California
Young, 1972:92	<i>Ocythoe tuberculata</i>	3	♀	12-80 ML	NE Pac.	Southern California
Roper & Sweeney	<i>Ocythoe tuberculata</i>	1	♀	310 DML		Southern Australia

*DML - Dorsal Mantle Length; VML - Ventral Mantle Length; ML - Mantle Length (Aspect unknown); BL - Body Length (Mantle & Head); TL - Total Length.

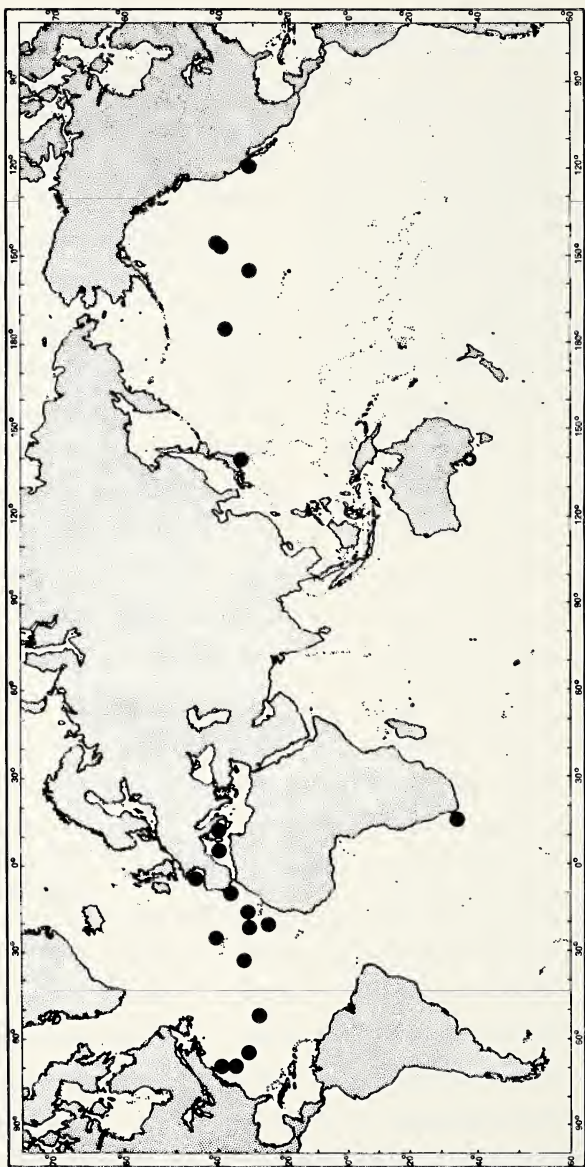


Figure 1. Geographical distribution of *Ocyropsis tuberculata*. Dots may represent more than one record where localities are close together (see Table 1.).

The anatomy of *Ocythoe tuberculata* has been described and illustrated by several authors, and the references are cited because they represent specimens not necessarily referred to in Table 1. Illustrations of the whole female and male animals are given by Jatta (1896), Naef (1923), and Young (1972). The internal anatomy was described by Jatta (1896), Marchand (1907), and Naef (1923). The radula was illustrated by Brock (1880) and Young (1972). Verany & Vogt (1852) and Naef (1923) described the spermatophore. The beak was figured by Jatta (1896) and Iverson & Pinkas (1971). Naef (1928) described the embryology.

AUSTRALIAN SPECIMEN

The specimen was given to the South Australian Fisheries Department after it was discovered stranded on the beach at Port Macdonnell, South Australia, during a storm on 9 August 1973. The body was strongly compressed, probably because the animal had lain on the beach for some time. The mantle length is 310 mm dorsally and 270 mm ventrally, although both values may have been slightly affected by the flattening of the mantle. Even so, this specimen represents the largest recorded to date, the maximum previously reported was the 280 mm (presumed mantle length) specimen of Verany (1851). The specimen is a mature female with approximately 104,000 eggs (volumetric determination) in the ovarian sac and oviducts. The eggs measure 1.75 mm in length and 1.00 mm in width (average of a number of measurements). No embryos were found in the narrow, unexpanded oviducts, and the eggs, all nearly identical in size, appeared to be unfertilized. There are 19 and 20 lamellae on the outer and inner demibranchs, respectively, of both gills. Measurements and counts of the specimen are presented in Table 2.

Table 2. Measurements (in mm) and counts of female specimen of *Ocythoe tuberculata* from South Australia.

Dorsal Mantle Length*		310
Ventral Mantle Length		270
Arms -	Left.....Right	
I	Broken.....	500
II	360.....Broken	

III	335	340
IV	410.....	400
Number of Gill Lamellae -		
Left (outer demibranch).....		19
Left (inner demibranch).....		20
Right (outer demibranch).....		19
Right (inner demibranch).....		20
Number of Eggs (volumetric measure).....		104,000
Size of Eggs (average)		
Length.....		1.75
Width.....		1.00

* Measured from posterior tip of the mantle to midpoint between the center of the eyes.

DISTRIBUTION

The occurrence of *O. tuberculata* in the waters of South Australia represents a considerable extension in the range of this species. The majority of records of *O. tuberculata* have been concentrated in the northern hemisphere, primarily in the western Mediterranean Sea and the eastern North Atlantic (Canaries, Azores, and Madeira) and less frequently in the western North Atlantic (Sargasso Sea, Gulf Stream) (Figure 1).

We include an additional record of *O. tuberculata* from the Mediterranean Sea, a female, 62 mm ML, captured at the surface (USNM 727831), as well as specimens from off Bermuda: 1 male, 9 mm ML, at 200 m (USNM 728669) and 1 male, 6 mm ML, at 96-102 m (USNM 728670).

Other records come from the eastern North Pacific off southern California and the western North Pacific off Japan (Figure 1). It has not been recorded previously from the Indian Ocean or from the entire central Pacific Ocean. Only a single record exists for the entire southern hemisphere, that from the South Atlantic off South Africa (Voss, 1967).

Since the sole South Australian specimen was found washed ashore after a storm, little can be stated about its probable natural location. Knox (1963) stated that warm surface currents run eastward from the Indian Ocean during April through November, north of the cold West Wind Drift, with an apparent reversal in direction

during the austral summer. If currents during the period around 9 August 1973 conformed to this pattern, it seems possible that the specimen could have come as a stray from the west and indicates that the species may indeed occur in the Indian Ocean. It is interesting to note that the extensive ENDEAVOUR investigations in the great Australian Bight did not capture the species (Berry, 1918).

The occurrence of *O. tuberculata* off South Africa also may indicate its presence in the Indian Ocean as the Agulhas Current is a strong, persistent outflow capable of dispersing animals from that ocean towards the Atlantic. On the other hand, the Agulhas Current can act as a cool, forceful barrier to the eastward extension of a warm water species from the Atlantic. Until specimens are captured in the Indian Ocean proper, the occurrence of *O. tuberculata* there will remain somewhat problematical.

The question of the existence of *O. tuberculata* in the broad expanse of the Pacific Ocean is answered in an unpublished report on the cephalopods collected by National Marine Fisheries Service vessels from the Fisheries Center in Hawaii (Burgess, unpublished). That report lists the following eleven specimens (sex not given) from the central North Pacific:

- 1 specimen, 15 mm ML, 32°12'N 154° 48'W
- 1 specimen, 55 mm ML, 37°54'N 174°46'W
- 2 specimens, 20.35 mm ML, 38°32'N 147°16'W
- 5 specimens, 18-80 mm ML, 39°49'N 146°25'W
- 2 specimens, 15.23 mm ML, 40°00'N 145°00'W

R. E. Young (pers. comm.) reports no specimens of *O. tuberculata* in the waters around Hawaii, in spite of intensive sampling effort during recent years. All specimens listed above are concentrated well north of Hawaii, although NMFS surveys have extended throughout the central North Pacific and southward to the Equator.

Therefore, *Ocythoe tuberculata* appears to be a cosmopolitan epipelagic species in warm waters of the world, but some intriguing gaps remain in its currently recorded distribution, particularly in the Indian Ocean and the southern hemisphere. One other pattern appears to emerge from the records. Captures of *O. tuberculata* occur primarily in the vicinity of land masses and islands, although oceanic captures do occur. The absence of *O. tuberculata* from intensively surveyed areas of the Atlantic, Pacific, and Indian Oceans where oceanographic conditions appear conducive to its occurrence remains to be explained by a more intensive study.

The depth distribution of *O. tuberculata* appears to be limited to the near-surface waters.

The closing-net captures recorded above from the Sargasso Sea and the Mediterranean occurred at the surface, 100 m, and 200 m. Other captures are presumed to be from near the surface, and some were taken right at the surface or by divers. Jobin (1937) records open-net captures from 50 m to 1000 m, but undoubtedly the deeper records are incorrect and the specimens were captured at shallower depths when the open net was retrieved.

BIOLOGICAL NOTES

A marked sexual dimorphism occurs that results in an extreme disparity of size at maturity. Females attain a dorsal mantle length (DML) in excess of 300 mm, the largest recorded to date being the South Australian specimen at 310 mm. Unfortunately, Rafinesque did not give the size of the holotype, but it must have approached that of the Australian specimen, as he said it was as large as a man's head and weighed 15 pounds. Males, on the other hand, remain small and apparently do not exceed a DML of about 30 mm (Table 1). Males have an extraordinarily well-developed hectocotylus on the third right arm, the structure of which is described in detail by Naef (1923). The hectocotylus, containing the spermatophores, is detached during mating and remains in the mantle cavity of the female during an extended period of fertilization.

The count of 104,000 eggs from the South Australian specimen indicates the high fecundity in *Ocythoe*. Naef (1923) had estimated 100,000 eggs in one of his specimens. Size of the eggs is very small, 1.75 mm in length and 1.00 mm in width. A large number of small eggs apparently is the rule in epipelagic octopods, as *Tremoctopus violaceus*, for instance, has been known to carry 139,000 eggs, the smallest of which were 3.6 mm long and 2.1 mm wide and presumably were fertilized (Hamabe, 1973).

Ocythoe tuberculata is reported to be viviparous, several authors having observed embryos in various stages of development in broadly expanded oviducts. While Jatta (1896) found embryos ready to hatch, Naef's (1923) specimens were in earlier stages of development. Sasaki (1929) claimed that the embryos developed in the "renal sacs," but this seems a curious and un hospitable site for embryonic development. We suggest that the renal sacs of Sasaki's specimen may have been damaged or poorly preserved to the extent that embryos were washed in from the oviducts or ruptured ovarian sac. The oviducts of the South Australian specimen were narrow and unexpanded and the

eggs contained therein showed no indication of development. No hectocotyls were present in the mantle cavity, so even though this specimen is very large and fully mature, it apparently had not mated.

Jatta (1896) observed that the male *Ocythoe* resides in the empty pallial chamber of the pelagic salp, *Salpa tilesii*. Apparently this interesting association is a universal trait, as Hardwich (1970) while SCUBA diving observed a male *O. tuberculata* in the test of the salp, *Tethys vagina*. The octopod deserted the test when first disturbed, then re-entered it and was captured. While Naef (1923) commented on the possible phylogenetic significance of this behavior in relation to the evolution of the shell in the related *Argonauta* (females only), additional observations are required before any behavioral or phylogenetic conclusions can be made.

A considerable number of epipelagic predators reportedly prey on *O. tuberculata* including the lancetfishes, *Alepisaurus borealis* (by Berry, 1955) and *A. ferox* (by Rees & Maul, 1956); the tunas, *Thunnus alalunga* (by Iverson, 1971), *T. thynnus* (by Pinkas, 1971), and *Germon germon* (by Bouxin & Legendre, 1936); and Risso's dolphin, *Grampus griseus* (by Jouvin, 1900). The vertical ranges of these predators, where known, are fairly extensive, so we are unable to precisely relate this predation to the vertical distribution of *O. tuberculata*, although indications are that it encompasses the upper 100-200 m.

ACKNOWLEDGEMENTS

We thank Brian Smith for the opportunity to examine the specimen and for permission to use it for the basis of our review of distribution and biology. We also are grateful to Harald Rehder, NMNH, for the translation of Rafinesque's original description and for additional aid in interpreting peculiar Rafinesqueian words. We appreciate the assistance of Richard E. Young, University of Hawaii, who secured information concerning records of specimens in the central Pacific Ocean. C.C. Lu and J. Rosewater kindly read the manuscript.

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MANGROVE AND SEAWALL OYSTER COMMUNITIES
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INTRODUCTION

Studies of aquatic macroinvertebrates are important for several reasons: first, the kinds of invertebrates present can be diagnostic of faunal areas and community structure thereby serving to compare local ecotypes with those of faunistic studies in other areas (Collard and D'Asaro, 1973); second, the aquatic macroinvertebrates furnish food for fish, many of which are of game and commercial value (Carter et al., 1973); and last, these organisms are often regarded as important indicators of water quality (Hester and Dendy, 1962). It is obvious from the available literature that the marine environment of fingerfill canals along the Gulf of Mexico deserves particular attention. Few authors have studied the littoral communities in these man-made waterways (e.g., Trent, Pullen and Moore, 1972; and Gallagher and Reid, 1974) comparing them to their natural-system counterparts. The present study seeks to offer such a comparison of the inhabitants associated with a typical local hard substrate colonizer, *Crassostrea virginica*. An attempt will also be made to analyze community changes from the mouth to the head of either a natural or a man-made system.

METHODS AND MATERIALS

The Study Area

The study area is centered on the southwest coast of Florida at 25° 57' North Latitude, roughly the juncture of the Carolinian and West Indian faunal provinces and at the approximate northern limit of the great mangrove-dominated forest that makes up The Ten Thousand Islands, Florida. From the northeast the area known as the Big Cypress Swamp stretches down to the east of the study area until it unites with the Ten Thousand Islands. Marco Island, the largest and northernmost of these islands, has undergone the rapid transformation from a mangrove island to a residential waterfront development in recent years, although man's presence on the island dates back to at least 1500 B.C. (Tebeau, 1957).

Sampling Procedures

Oyster community sampling was confined to the vertical concrete seawalls in the man-made waterway systems and to the intertidal prop roots of the red mangrove tree, *Rhizophora mangle*, in the natural waterway systems. Both of these substrates appeared to support a relatively uniform population of the eastern oyster, *Crassostrea virginica*. The oysters in turn form the habitat for a rather diverse, predominately invertebrate community. The collection method involved the encirclement of the intertidal oyster community on the vertical seawalls by a one square meter frame. The encircled area was then cleared of its attached oyster community by prying and scraping with a straightened mason's hoe. Intertidal mangrove prop roots were also encircled by the frame. Each root falling within the frame was cut at ground level and above the maximum height of oyster attachment. It should be noted that whereas the seawall represented a two dimensional (1m) surface area for attachment, the prop roots were three dimensional and presented nearly twice the surface area for attachment. All of the oysters and their associated fauna from each sample were caught in a 45 cm x 20 cm bottom net and then placed in 10% formalin for preservation. Twenty stations, randomly selected along the axis of natural and man-made systems, were sampled in this manner from October 1972 to July 1974. All samples were then sorted for community inhabitants and the organisms identified to the lowest possible taxa and counted. The combined community wet weight was determined to the nearest .1 kg. Twelve additional stations were selected in natural and man-made waterway systems to test for differences in the ratio of dead to live oysters and a subsample of 30 oysters was removed from each and the Condition Index or C.I. (Engle, 1950) determined.

$$C.I. = \frac{\text{Meat Weight} \times 100}{\text{Shell Volume}}$$

The shell volume was determined by subtracting the volume of water displaced by the empty valves

from the volume of water displaced by the live oysters (Galtsoff, 1964). The meat from each oyster was dried for 5½ hours at 80°C in a drying oven and weighed. At least 20 different oysters from each subsample were treated in this manner.

RESULTS AND DISCUSSION

The type of hard substrate community that is found in the Gulf of Mexico has been discussed by numerous authors (Collard and D'Asaro, op. cit.; Coomans, 1969; McDougall, 1943; Parker, 1960; Tabb et al., 1962; and Wells, 1961).

In the present study 24 molluscan species were identified in addition to the oysters themselves, and of these 12 were found at both natural and man-made stations: *Diodora cayensis*, *Littorina scabra angulifera*, *Crepidula plana*, *C. aculeata*, *Urosalpinx perruguta*, *Pisania tincta*, *Opisthobranchia* sp., *Aplysia wilcoxi*, *Musculus lateralis*, *Branchiodontes exustus*, *Lithophaga bisulcata*, and *Lasea adansoni*. Nine species were found exclusively in mangrove collections: *Turitella* sp., *Melongena corona*, *Anachis semiplicata*, *Bulla striata*, *Hysselodoris* sp., *Arca imbricata*, *Cardiamera floridana*, *Pseudourus typica* and *Martesia striata*. Three species were found exclusively at man-made stations: *Haminoea elegans*, *Barbatia candida*, and *Mytilopsis leucophaea*. The highest molluscan diversity was found at a natural station. Only *Branchiodontes exustus* was ubiquitous in occurrence and an obvious co-dominant mollusk with the oyster. The borer *Lithophaga bisulcata* was, however, well represented at a variety of natural and man-made stations. Though annelid identifications were only to the family level, it was obvious that relatively few polychaete species (9) could tolerate the intertidal hard substrate habitat. Those families represented included the Sigalionidae, Hesionidae, Nereidae, Cirratulidae and Sabellidae. An unidentified cirratulid was abundant, though extremely clumped in its distribution. Massive entanglements of many individuals of this species were found at a few stations.

Isopods and amphipods were abundant in nearly every collection. Taxonomic difficulties precluded proper identification, however. *Sphaeroma terebrans* was observed boring in nearly every mangrove prop root, testifying to the observations of Rehm and Humm (1973). Only those *S. terebrans* collected among the oysters themselves were counted for the purposes of this study. The Cirripedia, earliest colonizers of these substrates were present, but were not counted except at three stations where dead to live ratios

were determined: the ratio at the mouth of a man-made waterway was .21 and the ratio increased to .46 at the head of the waterway. A natural station in proximity to this waterway produced a .39 dead to live ratio. Thirteen other crustaceans were collected: *Palaemon floridanus*, *Periclimenes longicaudatus*, *P. americanus*, *Synalpheus fritzmulleri*, *Thor floridanus*, *Petrolisthes armatus*, *Eurypanopeus depressus*, *Panopeus occidentalis*, *Neopanope texana*, *Eurytium limosum*, *Menippe mercenaria*, *Ocypode quadrata*, and *Aratus pisonii*. *Petrolisthes armatus*, a filter-feeding porcelainid crab was, by far, the numerical dominant. This one species rivaled the amphipoda in abundance. Large numbers of the zoea and megalops of this species have been observed in man-made waterways (Courtney, 1974; Hatcher, personal communication). Of the several predacious crabs collected, *Eurypanopeus depressus* and *Eurytium limosum* were found at nearly every station in large numbers.

At least seven species of ascidians were collected, the styllids being the numerical dominants. While the methods of collection did not completely eliminate the problem of escape, six fish species were collected: *Gobiosoma robustum*, *Lagodon rhomboides*, *Archosargus probatocephalus*, *Gobiesox strumosus*, *Bathygobius soporator* and *Microgobius gulosus*.

It is helpful to look at each sampling station as a community unto itself. The pattern of a few common species associated with many rare species is characteristic of community structure. Stress tends to reduce the numbers of rare species and to concentrate dominance in a few common species. The Shannon Function ($\bar{H}$) or index of diversity combines variety and evenness components as one overall index which can be used for making comparisons among stations (Odum, 1971). Higher $\bar{H}$ values indicate greater diversity. Table 1 ranks the stations by order of decreasing diversity indices.

Natural station diversities appear to be not significantly different from those at man-made stations. There is a downward trend in diversity as one proceeds in to the heads of both natural and man-made systems. Four of the seven lowest ranked diversities are at the heads of such systems. The relatively poor showing for stations 31 and 32 may be attributed to reduced protective substrate at these natural stations, since there were relatively few oysters in the square meter sample from each (0 and 9.07 kg, respectively). Natural communities had a wet-weight average of 23.1 kg per station, while man-made stations averaged 18.3 kg.

Table 1. The Shannon Index* of diversity for each oyster community station, ranked in descending order.

STATION	H	STATION	H	STATION	H
1	2.174	21**	1.900	2	1.520
3	2.171	13	1.853	7	1.521
4	2.058	12	1.751	9	1.325
6	1.982	26**	1.730	22**	1.017
20**	1.909	25**	1.597	10	1.017
8	1.908	11	1.590	32**	.815
			31**	0	

$$* \bar{H} = - \sum \frac{n_i}{N} \log_e \frac{n_i}{N}$$

Where n_i is the number of individuals of a species and N is the sum of all individuals of all species.

** = Natural mangrove stations.

The condition indices depicted in Table 2 indicate that the oysters on the seawalls have a higher average condition index (10.79) than their natural system counterparts (6.94). A general decrease in condition was noted with distance into both natural and man-made systems.

Table 2. Condition Index (C.I.) and dead to live oyster ratio comparisons between man-made and natural systems.

Natural System	C.I.	Ratio
Mouth	7.55	.94
Middle	6.50	.59
Head	6.95	.80
Man-made System		
Mouth	12.50	2.27
Middle	11.64	14.62
Head	11.05	5.07

The condition index was higher in the man-made system than in the natural system indicating more meat per volume of shell, but the

ratio of dead to live oysters was lower and more stable than in the natural system indicating a greater percent of living animals.

The results of this study show that oysters settle on seawalls in numbers equal to their natural system counterparts, the mangrove prop root oysters. Further, a large majority of the oyster community inhabitants find local man-made systems conducive to their development and survival. A multitude of factors (e. g., physical and chemical tolerances; tidal flushing rates; climatology; etc.) can account for the presence or absence of particular species. Clumped distributions were found to be the rule rather than the exception.

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THE SHALLOW WATER MARINE MOLLUSKS OF THE SWAN ISLANDS, HONDURAS

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The Swan Islands (17°24'N; 83°55'W) are small emergent crests of the Bonacca Ridge system in the western Caribbean. They lie approximately 590 miles SSW of Miami, 350 miles WSW of Jamaica, and 175 miles ENE of Roatan, Honduras. Little Swan is the eastern-most island.

It is about 1½ miles long and has a maximum width of about ½ mile. Great Swan is separated from the little island by 400 yards of shoal reef which is usually subjected to very strong currents.

The larger island is slightly more than two miles long and has a maximum width of about ¼ mile. A third small low rocky outcrop, Booby Cay, lies off the southwestern coast of Great Swan, separated from it by a shallow narrow channel.

There have been few collections of mollusks made at the Swan Islands. Fifty-seven lots (216 specimens) of marine mollusks collected by C. H. Townsend prior to June, 1887, are deposited in the National Museum of Natural History. I have located and examined 35 of these lots (163 specimens), confirming their identifications. George Nelson explored the Swan Islands in April, 1913. He brought back a collection of marine and terrestrial mollusks to the Museum of Comparative Zoology, Harvard University. Some of the land snails were subsequently deposited in the Academy of Natural Sciences of Philadelphia. Clapp (1914) described the land snails collected by Nelson. The collection of marine mollusks consisted of 113 lots deposited in the MCZ. I have located and confirmed identifications for 67 of these lots. Pilsbry (1930) re-examined the land snails collected by Nelson and reported on additional terrestrial mollusks collected from the Swan Islands by the Pinchot Expedition in April, 1929. Apparently no marine specimens were taken during the latter expedition.

There are only a few scattered reports of marine mollusks from the Swan Islands in the literature. The majority of these have been lines from "Specimens Examined" sections of various *Johnsonia* reports. The first four volumes of *Johnsonia* have recorded only 21 species from the Swan Islands. Thus, this present paper significantly increases the number of mollusks known to occur at or near the Swans. A total of 159 mollusks have been identified as follows: 115

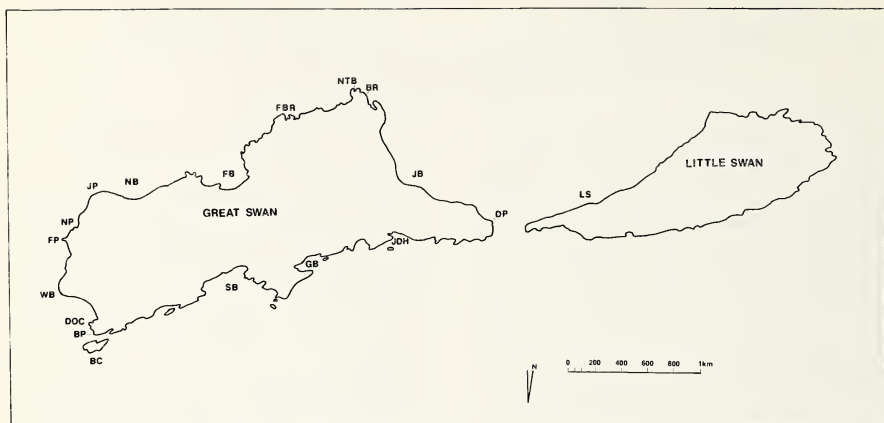
Gastropoda, 34 Bivalvia, 8 Amphineura, and 2 Cephalopoda.

Since 1973 Texas Christian University personnel have participated in three trips to the Swan Islands. The first trip was from April 16-22, 1973, the second from July 17 to August 13, 1974, and the last from January 7-21, 1975. I participated in the first and last trips collecting mollusks and other invertebrates, whereas Dr. Donald E. Keith and Mr. Louis Tortora kindly provided the mollusks from their 1974 venture. Every available collecting technique was employed including beachcombing, detailed quantitative analysis of hard-bottom intertidal substrates, underwater collecting by snorkel and SCUBA techniques, and shoveling and screening of shallow bottom loose substrates. Due to lack of an appropriate vessel, dredging was not possible. The collecting localities are shown in Figure 1.

Figure 1: Map of the Swan Islands showing collecting localities. Localities as follows: BC, Booby Cay; BP, Buffalo Point; BR, Blowing Rock; DOC, rocks immediately south of the dock at Harbor Bay; DP, Dillard Point; FB, Fowler's Bay; GB, Goat's Bay; JB, Jacobson's Bay; JDH, Jim Duff's Hole; JP, James' Point; LS, reef off the northern coast of Little Swan; NB, North Beach (James' Bay); NP, Northwestern Point; NTB, Natural Bridge lagoon; SB, Smith's Bay; WB, western-most beach at Mack Point.

The littoral and shallow sublittoral (less than 12 m depth) marine environments around the lands are composed of four ecologically distinct components: 1) loose sand (with beach and subtidal units), 2) *Thalassia*-stabilized sand, 3) rocky intertidal (with ironshore and coral rubble units), and 4) spur and groove patch reefs. Since the majority of the collections were made off Great Swan Island, the descriptions which follow emphasize the environments there.

Loose sandy beaches occur at Harbor Bay, Mack Point, North Beach, Fowler's Bay, Jacobson's Bay, and Smith's Bay. There are additional minor sandy patches at smaller inlets around the island. Extensive loose sublittoral



GASTROPODA

FAMILY	SPECIES	MCZ	USNM	BC	BP	BR	DOC	DP	FB	FBR	FP	GB	JB	JDH	JP	LS	NB	NP	NTB	SB	WB
LITTORINIDAE																					
	<i>ECHININUS NODULOSUS</i>	x											*							*	
	<i>LITTORINA FLOCCOSA</i>				*																*
	<i>LITTORINA LINEOLATA</i>				*			*			*										*
	<i>LITTORINA MELEAGRIS</i>				*										*						
	<i>LITTORINA ZICZAC</i>	x	x	*	*	*	*	*	*		*	*	*	*	*	*				*	*
	<i>MODIOLITTORINA TUBERCULATA</i>			*	*	*	*	*	*		*	*	*	*	*	*				*	*
	<i>TECTARIUS MURICATUS</i>	x	x	*	*	*	*	*	*		*	*	*	*	*	*				*	*
MAGILIDAE																					
	<i>CORALLIOPHILA ABBREVIATA</i>		x		o														Δ		
	<i>CORALLIOPHILA ABERRANS</i>				o														Δ		
	<i>CORALLIOPHILA CARIBAEA</i>												Δ						Δ		
MARGINELLIDAE																					
	<i>HYALINA ALBOLINEATA</i>												o								
	<i>HYALINA AVENA</i>	x			o								o								
	<i>MARGINELLA LACTEA</i>				o																
	<i>MARGINELLA SP.</i>				o																
	<i>PERSICULA FLUCTUATA</i>																		o		
	<i>PERSICULA PULCHERRIMA</i>	x																			
	<i>PRUNUM CARNEUM</i>				o																
	<i>PRUNUM GUTTATUM</i>	x		o	o																o
MITRIDAE																					
	<i>NITRA BARBADENSIS</i>				o																
	<i>NITRA FLORIDA</i>		x		o																o
MODULIDAE																					
	<i>MODULUS MODULUS</i>																				o
MURICIDAE																					
	<i>DRUPA NODULOSA</i>				o																o
	<i>MUREX POMUM</i>		x										Δ						Δ		
	<i>PURPURA PATULA</i>	x	x	*	*	*		*	*	*	*	*	Δ						*		
	<i>THAIS DELTOIDEA</i>			*	o					*			Δ			Δ	Δ				o
	<i>THAIS RUSTICA</i>				o																
NASSARIIDAE																					
	<i>NASSARIUS ALBUS</i>												I						I		
NATICIDAE																					
	<i>NATICA CANRENA</i>	x																			
	<i>POLINICES LACTEUS</i>	x		o	o								I								o
NERITIDAE																					
	<i>NERITA PELORONTA</i>	x	x	*	o	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	<i>NERITA TESSELLATA</i>	x	x	*		*		*	*	*	*	*	*	*	*	*	*	*	*	*	*
	<i>NERITA VERSICOLOR</i>	x	x	*	o	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	<i>SMARAGDIA VIRIDIS</i>															o					

[illegible]

<i>SENELEDIAE</i>								
<i>SEMELE PROPICUA</i>	x							
<i>SPONDYLIDAE</i>								
<i>SPONDILUS AMERICANUS</i>								O
<i>TELLINIDAE</i>								
<i>ARCOPIAGIA FAUSTA</i>	x	x		O	I		I	O O
<i>TELLINA AEQUISFRIATA</i>							O	
<i>TELLINA GOULDII</i>	x							
<i>TELLINA INTERRUPTA</i>	x							
<i>TELLINA LISTERI</i>	x			O				
<i>TELLINA RADIATA</i>	x			O			O	O
<i>STRIGILLA FLEXUOSA</i>	x							
<i>STRIGILLA MIRABILIS</i>				O				
<i>VENERIDAE</i>								
<i>CHIONE CANCELLATA</i>								

<i>CHITONIDAE</i>						
<i>ACANTHOPLEURA GRANULATA</i>	x	*	*	*	*	* * *
<i>CHITON MARMORATUS</i>		*		*	*	* *
<i>CHITON SCAMOSUS</i>		*				* *
<i>CHITON TUBERCULATUS</i>		*		*	*	* *
<i>CHITON VIRIDIS</i>					*	
<i>CRYPTOPLACIDAE</i>						
<i>ACANTHOCHITON SPICULOSA</i>						Δ
<i>ISHNOCHITONIDAE</i>						
<i>ISHNOCHITON LIMACIFORMIS</i>						Δ
<i>LEPIDOCHITONIDAE</i>						
<i>LEPIDOCHITONA LIOZONIS</i>						Δ
<i>MOPALIIDAE</i>						
<i>CERATOZONA SQUALIDA</i>						Δ

<i>LOLIGINIDAE</i> (???)	
<i>SQUID</i> <i>SP.</i>	×
<i>OCTOPODIDAE</i>	
<i>OCTOPUS</i> <i>SP.</i>	Δ

sand occurs in Harbor Bay, parts of James' Bay off North Beach, and off Booby Cay. Sand is seasonal in the channel between Booby Cay and Great Swan Island; it is present in the summer but removed by currents in the winter. Shell debris accumulates on all sandy beaches, but those at Mack Point and a small sandy area just south of Buffalo Point have proved to be highly productive shell drops. No living mollusks were collected from intertidal or subtidal loose sands. A few paired valves of *Arcopagia fausta* and *Codakia orbicularis* were recovered from the sandy floors of Harbor and James' Bays.

Thalassia-stabilized sand flats are major ecological units in shallow sublittoral areas throughout the Caribbean. However, the *Thalassia* flats of Great Swan are poorly developed. The largest grass-stabilized area is in James' Bay off the eastern end of North Beach. It lies behind one of the best reefs off the island. Nevertheless, these grass beds are patchy and rarely at a depth of more than one meter below msl. Less extensive *Thalassia*-stabilized sand occurs at Jacobson's Bay and Smith's Bay. Mollusks most commonly associated with this habitat include *Cerithium atratum*, *C. eburneum*, *C. literatum*, *Columbella mercatoria*, *Modulus modiolus*, *Nassarius albus*, *Polinices lacteus*, *Vasum muricatum*, *Strombus gigas*, *S. raninus*, *Tonna maculosa*, *Bulla occidentalis*, *Codakia orbicularis*, *Lucina pensylvanica*, and *Arcopagia fausta*.

The dominant littoral habitat of Great Swan Island is the calcareous ironshore (see Doran, 1954, or Abbott, 1958, for an explanation of the term). Almost all of the southern coast (except Smith's Bay) is ironshore, as are the northern shores between bays and east of Jacobson's Bay. A pattern of intertidal zonation similar to that described by Lewis (1960) for Barbados is evident.

The supralittoral ironshore is dominated by *Tectarius muricatus* and *Nodilittorina tuberculata*. *Echininus nodulosus* occurs in significantly fewer numbers than any of the other common Swan Island littorines. *Littorina ziczac* is very abundant in the splash zone, as is *Nerita peloronta* and *N. versicolor*. The lower littoral ironshore is characterized by *Acmaea leucopleura*, *A. pustulata*, *Diodora listeri*, *Fissurella angusta*, *F. nodosa*, *Cittarium pica*, *Purpura patula*, *Chiton marmoratus*, *C. squamosus*, *C. tuberculatus*, and *Acanthopleura granulata*. Quantitative studies of the intertidal ironshore of Great Swan Island are in progress.

Coral rubble occurs in the intertidal zone along portions of North Beach, Jacobson's Bay, Fowler's Bay, Smith's Bay, and on the eastern side of the channel between Booby Cay and Great

Swan Island. Mollusks of the ironshore may be found at appropriate levels in coral rubble. A few additional species are characteristic of the rubble: *Nerita tessellata*, *Planaxis nucleus*, *P. lineatus* and *Arcopsis adamsi*.

A true fringing reef with typical morphology is wanting off any portion of Great Swan Island. Spur and groove patch reefs form the dominant shallow sublittoral habitat. Tortora (1975) has identified 17 species of Scleractinia and 12 species of Octocorallia from the Swan Islands reefs. Mollusks commonly found in association with the reef complex include *Engina turbinella*, *Pisania pusio*, *Columbella mercatoria*, *Conus mus*, *Leucozonia nassa leucozonialis*, *L. ocellata*, *Hipponix antiquatus*, *Coralliophila abbreviata*, *C. aberrans*, *C. caribaea*, *Drupa nodulosa*, *Murex pomum*, *Thais deltoidea*, *Cyphoma gibbosum*, *Arca imbricata*, *Barbatia cancellaria*, and *Petricola lapicida*. A complete list of the mollusks from the Swan Islands is given in Table 2.

There are two species among the Swan Islands fauna worthy of note. *Mitra florida* was found in beach drift on several occasions, an apparent range extension for the species. A single young (less than 5 mm) living specimen of *Calliostoma adelae* was collected from the base of a gorgonian off James Point during the summer, 1974. Although small, the specimen has the typical features of *C. adelae* (Clench & Turner, 1960). It is quite different from *C. jujubinum* which also occurs at the Swans. Prior to this report, *C. adelae* was known only from southern Florida.

A comparison of the Swan Islands fauna with that of other Caribbean localities is of interest. The Swan Islands seem to have fewer kinds of habitats than most other nearby islands. There are no fine-grained shallow water sediments, no mangrove forests, very little grass-stabilized sand, and no estuarine conditions. Some or all of these ecosystems occur at Grand Cayman (Abbott, 1958); Panama (Olsson & McGinty, 1958); Belize, formerly British Honduras (Robertson, 1963); Costa Rica (Houbrick, 1968); Los Roques (Work, 1969); and Roatan, Honduras (personal observation). Thus, the total diversity of mollusks at these localities should be greater than at the Swan Islands.

Table 1: A comparison of the Swan Islands molluscan fauna with those of three other Caribbean localities. *tot* total numbers; *com*: numbers in each category which occur at both localities. Numbers are counts of species (*not* subspecies); Pteropoda, Vermitidae, and Aplysiacea are excluded here.

Table 1								
	GASTROPODA		BIVALVIA		AMPHINEURA		TOTALS	
	tot	com	tot	com	tot	com	tot	com
Swan Islands	112	---	32	---	9	---	156	---
Grand Cayman	194	81	72	24	11	7	277	112
Costa Rica	181	51	38	14	8	3	227	68
Los Roques	80	50	34	18	3	2	117	70

As one compares the known Swan Islands fauna with those reported by the above authors, certain difficulties become apparent. Simple lists of numbers of species (as in Table 1) may express differences in habitat diversity or possibly differences in collecting technique or season. Olsson & McGinty's (1958) report of 534 species and subspecies probably approaches the actual diversity which occurs off Panama; however, this report does not emphasize habitat relationships. Robertson (1963) gives an excellent account of habitats but does not include a complete list of the collected species. Of these papers, only Abbott (1958), Houbbrick (1968), and Work (1969) provide

sufficient habitat data and species listings to enable comparisons with the Swan Islands data. There are still additional difficulties with the comparisons. For example, Houbbrick gives strong emphasis to microfaunal beachdrift in his list of Costa Rica mollusks. At least 30 of the gastropods are beachdrift microfauna. The paucity of microgastropods at the Swan Islands may reflect inadequate collecting technique despite the specific attempt to search for them in January, 1975. In any case, the microfaunal difference between the two areas suggests that the collections, localities, or both are not exactly comparable.

SPECIES COMMON TO ALL LOCALITIES: 34		
	The percentage of mollusks at the Swan Islands which also occur at listed localities:	The percentage of mollusks at listed localities which also occur at the Swan Islands:
Grand Cayman	71.8%	40.4%
Costa Rica	43.6%	29.9%
Los Roques	44.9%	59.8%

Table 2: A list of the species of the Swan Islands mollusks. Symbols: MCZ, Museum of Comparative Zoology, Harvard; USNM, National Museum of Natural History, Washington, D.C.; *, rocky intertidal collected alive; Δ , reef-associated

collected alive; I, *Thalassia*-stabilized sand collected alive; o, beach drift (dead shells); x, present. Additional locality symbol explanations appear under the map, Fig. 1.

The Swan Islands mollusks show greatest correspondence with the nearby Grand Cayman fauna. Greater species diversity at Grand Cayman is also apparent. The poorest relationship between faunas is with that of Costa Rica. This is due in part to the differences in numbers of microfauna, but more importantly to numerous continental shore species at Costa Rica in habitats which are absent at the Swan Islands. It would be interesting to compare the Swan Islands mollusks with those of the Honduran Bay Islands, and hopefully this will soon be possible.

A relatively high percentage of Los Roques mollusks are also part of the Swan Islands fauna, but the reciprocal percentage is considerably less.

This probably represents the recruitment of southern Caribbean species at the Swan Islands by larval transport in prevailing surface currents. A more detailed analysis of individual faunal components at every locality is necessary before additional zoogeographical considerations should be attempted.

The collections of Swan Islands mollusks have been deposited in the Texas Christian University Museum.

Acknowledgements

Funds for this work were provided by the Texas Christian University Research Foundation and the Research Fund of the Department of Biology, Texas Christian University. I am also indebted to the Overseas Operations Division of the National Weather Service, NOAA, United States Department of Commerce, for providing logistics support and accommodations during each trip to the Swan Islands. Without their assistance, this work would not have been possible.

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NEW GEOGRAPHICAL LOCATION FOR *PHILOPHTHALMUS* SP. IN THIARID
SNAILS AND WATERFOWL IN TEXAS

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In 1964, two thiarid snails, *Tarebia granifera* (Lamarck) and *Melanoides tuberculata* (Müller), were reported in Brackenridge Park, San Antonio, Texas and in Landa Park, New Braunfels, Texas (Murray, 1964). Both species are important as trematode hosts in the Orient. *T. granifera* is the intermediate host of *Paragonimus westermani*, *Metagonimus yokogawai*, *Haplorchis taichui* and *Diorchitrema formosanum*. *Melanoides tuberculata* is the intermediate host of *Clonorchis sinensis* and *Diorchitrema formosanum* (Hunter, et al., 1960).

These snails were biannually surveyed for evidence of trematode cycles because of their parasitological significance and their proximity to numerous species of animals in the San Antonio Zoo. No trematode cycles were found until 1968 when the first trematode cycle in these snails in the western hemisphere was discovered (Murray & Stewart, 1968). The trematode was later identified as *Philophthalmus* sp., an ocular parasite of waterfowl and occasionally mammals (Murray & Haines, 1969). Identification was based on the morphology of the rediae, the megalurus type cercariae, and the flask-shaped metacercariae, diagnostic of the genus (Dawes, 1968). It was found that the areas of highest infection were close to and within the San Antonio Zoo, with a mean ratio of infected to uninfected snails of 1:3.

Repeated studies revealed no trematodes in these snails in the Landa Park area until September, 1974. In an effort to obtain uninfected *T. granifera* for electron microscopic studies, 20 snails were collected from one site. One of the 20 snails contained trematode rediae which were identified as *Philophthalmus* sp., the same as the Brackenridge Park snails.

Forty-five collecting sites were chosen so that most areas of the park would be sampled. Included among these areas were those which showed evidence of usage by waterfowl. Where possible, a sample of 50 *T. granifera* and 50 *M. tuberculata* was collected. All snails were kept at room temperature in water from the collecting site. Occasionally, artificial aeration was used;

however, none of the samples was kept over six days after collection. The presence of trematode infection was determined by smashing the upper spires of the shell to expose the hepatopancreas.

A total of 2007 *T. granifera* and 211 *M. tuberculata* were examined from the 45 sites. No infected *M. tuberculata* were found, probably due to the small numbers collected and to the preference of *Philophthalmus* miracidia for *T. granifera*. Thirteen of the 45 sites contained infected *T. granifera* and of the sites frequented by waterfowl, 78% yielded infected snails.

A high correlation between waterfowl usage and infected snails occurred close to and within the property of the Lower Colorado River Authority of Texas. These sites are protected from the public and are therefore used by a number of ducks. It is also in this area that a ratio of 1:16, the highest concentration of infected snails, occurred.

Philophthalmus sp. could have been introduced to Landa Park from any one or combination of three sources: (1) infected snails, (2) infected migratory waterfowl, or (3) infected waterfowl from the San Antonio Zoo. The only known source of infected *T. granifera* in Texas is the San Antonio Zoo and Brackenridge Park in San Antonio. It seems unlikely that anyone would take these snails to Landa Park because they are hard to obtain without collecting equipment. Migratory waterfowl could have introduced the parasite to Landa Park, but the Park Director indicates that migratory flocks have not been observed using the park. There have been waterfowl donated to Landa Park from the San Antonio Zoo and this is the most likely method of the parasite's spread.

In Landa Park, *Philophthalmus* sp. is of possible significance as a parasite of man. The positive sites in the lake above the public swimming pool and in the effluent below the pool indicate that, although no positive snails were found in the pool, miracidia are traveling through the pool. The pool has untreated artesian water coming directly from the lake to the pool which supports a large snail population. There is

sufficient water running through the pool to support a large population of snails, even in the winter when the pool is drained. In addition to the danger of snails in the swimming pool becoming infected, there is the danger of cercariae entering the pool with a potential consequence of human infection. A similar problem is encountered in the private swimming area, where two positive sites occurred. This is also untreated water in which people swim. *Philophthalmus* sp. have been successfully introduced to mammals through direct cercarial contact with the eye (Alicata & Ching, 1960). *Philophthalmus* sp. have also been reported in man in Asia (Penner & Fried, 1963), and as a possible human parasite in New Zealand (Howell, 1965). Consequently, there is some concern over persons swimming in both the public and private swimming areas in untreated water.

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MELANOIDES TUBERCULATA (MULLER),
LAS MORAS CREEK, BRACKETVILLE, TEXAS.

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In 1971, Dr. Joseph P.E. Morrison suggested that I collect *Popenaias* [*Elliptio*] *popei* Lea, from Las Moras Creek, Kinney County, Texas, where Dr. E.A. Mearns had obtained specimens in 1898. Extensive field work along the 48 km of Las Moras Creek in April, 1971, yielded no living *P. popei*, and additional attempts to obtain it in May, 1973, March, 1975, and June, 1975, failed. It is my opinion that *P. popei* has been extirpated from Las Moras Creek; furthermore, under present circumstances it is unlikely that this species will be re-established.

Photographs of the area were obtained on June 7, 1975, at which time the probable cause for the extirpation of *P. popei* was observed. A crew of five workers was methodically removing the heavy plant growth occurring in the creek. Large sickles were being used to rip the plants from the substrate, allowing large masses of plants, mud and debris to float downstream. This process, according to local owners, is repeated 2 or 3 times a year and started in 1971.

Although the possible extirpation of *P. popei* is important, a second discovery is certainly of equal significance. In April, 1971, the author was surprised to discover a population of the introduced thiarids, *Melanoides tuberculata*, in the headwaters of Las Moras Creek. The importance of *M. tuberculata*, and its close relative *Tarebia granifera*, as potential and actual intermediate hosts for trematodes in the United States was reported by Murray & Stewart (1968), Murray & Haines (1969), and Murray (1971).

Three unusual situations relate to the occurrence of *M. tuberculata* in Las Moras Creek. First, the introduction and spread of thiarids in the United States has been generally associated with large cities. I believe most populations were established by persons dumping the contents of unwanted aquariums in available streams (Abbott, 1952; Murray, 1971). Bracketville, Texas (population 1,530), on the north bank of the headwaters of Las Moras Creek and Fort Clark Springs, a resort facility on the south bank, make the total population of the immediate area less than 1,700 people.

Second, the habitat of Las Moras Creek is similar to the habitats in South Central Texas

where populations of 51,645 snails per m² occur (Murray & Wopschall, 1965). The artesian water of the creek is from the same underground source as that in South Central Texas, 241 km east. In Texas, thiarids normally exist in shallow, slow running water (0.6-1.2 m in depth) on a substrate consisting of soft mud or soft mud-sand combinations. In general, this habitat is repeated in Las Moras Creek. It was surprising, however, to find *M. tuberculata* occurring in a large pool (3-3.7 m deep) receiving over 7,570 liters of water per minute. The bottom and sides of the pool were lined with large rocks between which was fine sand on which the snails lived.

Third, the largest *M. tuberculata* collected in South Central Texas measured 40 mm in length. In April, 1971, dead shells measuring 70-80 mm were observed in Las Moras Creek, but the source of these large snails was not found. This observation was repeated in May, 1973. In March, 1975, M. Bowie Kotrla of Trinity University insisted we examine the deep pool mentioned above. It was here that the large 70-80 mm snails lived, and apparently they do not survive outside this pool. These are the largest *M. tuberculata* reported in the United States.

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SYMPOSIUM: ORGANIZER: DR. EMILY VOKES

EASTERN PACIFIC - WESTERN ATLANTIC FAUNAL AFFINITIES

GEOLOGIC HISTORY OF THE PANAMIC REGION

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The theory of plate tectonics provides us with some clues to the geologic history of the Panamic region, although by no means does it provide all of the answers. At the end of the Paleozoic Era South America, Africa, North America, and Eurasia had all come together to form a mega-continent. Then a great rift opened in what is now the Atlantic Ocean, pushing Europe and Africa to the east, North and South America to the west. In the middle Mesozoic the western margins of both the North and South American plates began to be pulled under by subduction and the mountains of the Sierra Nevada and Andes were initiated. Toward the end of the Mesozoic South America began to encroach on North America and an east-west trending range of mountains was created in the ancestral Caribbean Sea. Subsequently the North American plate has been moving westward more rapidly than the South American one and the intervening area has been wrenched apart by great transverse faults,

causing the fractionation of the mountain range into several parts: The Sierra Madre del Sur of Mexico; the Sierra Madre de Guatemala, Honduras, and Nicaragua; and the islands of the Greater Antilles. The down-dropped blocks between are the depths of the Caribbean. Continued westward movement by both plates, in addition, has resulted in a line of volcanoes from Guatemala to Panama that have connected up the two continents along what is now Central America.

The break between the two continents was open from late Mesozoic time until probably no more than 5 million years ago, when it was completely closed, creating a land barrier between the Atlantic and Pacific Oceans. The faunas, which had formerly been the same, were suddenly isolated and as evolution has progressed, new forms have appeared, with the result that today the majority of the species on both sides are very similar but no longer identical.

ATLANTIC ANCESTORS OF THE EAST PACIFIC FAUNA

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When one examines the fossil record it becomes apparent that almost the entire molluscan fauna of the tropical eastern Pacific (or Panamic) Province is directly descended from western Atlantic (specifically Caribbean) ancestors. This is a reflection of the effect of the ocean currents, caused by the rotation of the earth, during the interval when the interoceanic passageways were open. The similarity of the two faunas has long been known. However, there is but a small number of identical species common to the opposite sides of the Isthmian barrier. Studies during this century have almost doubled the number of species known from each region, but the number of species in common has not notably increased, undoubtedly reflecting a modern trend toward finer species definition ("splitting").

The state of our knowledge of the fossil record is also expanding at a rapid rate, so that the comparison of the two faunas made but a scant 10 years ago by Woodring has to be markedly revised. Of 43 genera or subgenera considered by Woodring as "paciphiles" (i.e., present in the fossil record of the western Atlantic but now extinct in that province while still living in the eastern Pacific) at least five have been discovered living in the western Atlantic, mostly off Brazil, formerly a "Terra Incognita" of mollusks. On the other hand, at least seven more genera of paciphiles, which were not known in 1966, can be added to the ranks. Woodring, conversely cites, only four "caribphiles" (those surviving in the Caribbean only), and these evidently represent basically Caribbean forms that attempted to colonize the Pacific coast but did not succeed.

THE MARINE MOLLUSKS OF SURINAM (DUTCH GUIANA)

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The coast of Surinam is about 338 kilometers long and stretches from east to west. There are no rocks, and the beaches consist of clay, mud and sandbanks; the bottom is flat. Along nearly the whole coast the places where mollusks can fix themselves to a substrate are trunks of *Avicennia*, the sea-dike west of Nieuw Nickerie, and, especially in the estuaries, the jetties or the banks strengthened by wood or stone.

The mollusk-fauna is poor; 144 species have been found washed ashore — 67 gastropods, one scaphopod, 75 bivalves and one cephalopod. An oceanic current runs from the Amazon River along the South American coast and transports water which is rich in mud. For this reason the coastal water is murky and does not clear until about 16 kilometers off the coast, this distance varying to the season. Further out the bottom gradually hardens, and the number of species grows, with more gastropods than bivalves. Where on the shelf the bottom is hard a very rich molluscan fauna is present; only a small part of this fauna has been dredged by the *Coquette* (a fishing-boat which investigated the possibility of fishing in depths up to 55 meters in 1959. She also procured mollusks on some journeys in 1963.) The number of known species has been considerably enlarged by material dredged by the *Snellius* and the *Luymes*. That material is now being sorted and studied. Therefore, we limit ourselves here to what has been washed ashore and has been found on the "shell-ridges."

The "shell-ridges" are shoals of sand and shells in the coastal region; they started out as shore banks deposited on the coast, the oldest being about 6,000 years old, the Young Holocene. In that same period a large trough-shaped bay around the Corantijn River was filled, so that Young Holocene shells were also found there, e.g., in Coronie-35 (near Totness) and Alliance-28 (near Alliance). The shell-ridge near Cupido at the Maratakka River is situated about 32 km from the coast, while near the Marowijne River the most inland ridge is only 5 kilometers from the coast.

Twenty species (14 gastropods, 6 cephalopods) are found only on shell-ridges. The gastropods are small to very small species and

may be overlooked in shore collecting or may still be obtained by offshore dredging. So of this group little can be said. But among the bivalves *Lucina pectinata* (Gmelin) and *Sanguinolaria cruenta* (Lightfoot) attract special attention because (1) they are found in more than one place, (2) are relatively large, and (3) have not yet been dredged. These may show that some change have taken place in the fauna in the last 6,000 years.

Of the 144 species (67 gastropods, 1 scaphopod, 75 bivalves, 1 cephalopod) which have been washed ashore, there are 84 (47 gastropods, 36 bivalves, 1 cephalopod) not collected by the *Coquette*, but many of these are known from drill-holes and/or from the shell-ridges. Few are living only in the upper part of the estuaries and the lower part of the rivers, but one may assume that most live near the coast. Of those which live in the surf, some species have been found alive.

Among the mollusks which are found on the coast the bivalves dominate. This may be due to appearance, because the gastropods are usually smaller, and, for instance, the two species of *Anachis* [*Parvanachis*] and the small opisthobranchs may be washed ashore in large quantities. But on the beach one arrives at the impression that the bivalves are far in the majority. Three species are the most conspicuous, namely *Crassostrea lacerata* (Hanley) (this name is preoccupied; a specialist should decide which name is valid and should be used), *Chione subrostrata* (Lamarck) and *Mulinia cleryana* (Orbigny), quoted in order of frequency. *Lunatia marochiensis* (Gmelin) and *Prunum prunum* (Gmelin) are the most common gastropods. The pulmonates should be mentioned separately, because they live on land or tree trunks (sometimes more than 2 kilometers from the coast) and use sea-water only for egg-laying. Of the four pulmonate species, *Melampus coffea* (L.) occurs most frequently, while *Ellobium pellucens* (Menke) is also common.

A survey of the species that have been found in the estuary of the Surinam River and farther up-stream before the Brokopondo-dam closed it follows. The water moves to and fro with the tides, and the percentage of salt in the water depends on the rainfall. The polyhaline water

penetrated sometimes to the jetty of Geyersvlijt (about 11 km up-stream), the mesohaline water began in the neighbourhood of Nieuw Amsterdam (about 6 km up-stream) and goes to about 35 km, the oligohaline from about 19 to 48 km and the fresh water began at about 35 km up-stream. The measurements have been carried out on surface water in 1939 and 1940.

Table 1 shows how the different species are distributed:

Table 1
Distribution of Species in the Suriname River

<i>Littorina scabra angulifera</i> (Lamarck)	
<i>Thais coronata trinitatis</i> (Guppy)	
<i>Neritina zebra</i> (Bruguiere)	polyhaline
<i>Melampus paranus</i> (Morrison)	
<i>Melampus coffea</i> (L.)	
<i>Ellobium pellucens</i> (Menke)	mesohaline
<i>Mytella charruana</i> (Orbigny)	
<i>Crassostrea lacerata</i> (Hanley)	
<i>Cyrenoida floridana</i> (Dall)	oligohaline
<i>Lignopholus clappi</i> (Turner)	
<i>Neoleredo reynei</i> (Bartsch)	
<i>Anticorbula sinuosa</i> (Morrison)	
<i>Corbicula rotunda</i> (Prime)	
<i>Psiloterredo healdi</i> (Bartsch)	

The specimens of *Neritina zebra* which were found in Jodensavanne had been used as food by the natives and thus do not count. Jodensavanne lies about 88 km up-stream and is the farthest inward locality investigated. The surface water is completely fresh, and so I suppose that the eggs of the last two species, namely *Corbicula rotunda* and *Psiloterredo healdi*, which are still found alive here, hatch only in deeper water.

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PACIFIC OUTPOSTS OF THE TERTIARY CARIBBEAN PROVINCE

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The occurrence of the muricid genus *Talityphis* in the Temblor Miocene (Round Mountain silt member), near Bakersfield, California, points up the extension of Woodring's "Tertiary Caribbean Province" northwestward from Panama to central California. Modern concepts of continental drift, sea-floor spreading, and plate tectonics help to explain the distribution of a warm-water tropical assemblage, such as the one in which the *Talityphis* occurred, to an area that is now much cooler. The elevation of the Isthmus of Panama cut off the Pacific fauna from its Caribbean roots; but, paradoxically, the fauna survived on the Pacific side much more prolifically

than it did on the Atlantic side, where current patterns were disrupted and temperatures markedly lower during late Cenozoic time. The fossil record in the Pacific is meager but shows that the warm-water element persisted in southeastern California into the Pliocene. Pliocene records in the Gulf of California and Panama prove its continuance, and Pleistocene occurrences are well distributed from Baja California to Ecuador. In spite of the steep, narrow continental slope, the old Tertiary Caribbean Province fauna persists here, its richest expression now in the environs of Panama Bay.

MARINE MOLLUSKS OF PANAMA BAY

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The spring tidal range at Panama City, Panama, is between 4.9 and 5.2 meters (16 to 17 feet), with broad expanses uncovered at low tide. Most intertidal areas, both east and west of Panama City, contain the expected species of mollusks. However, within the area west of Panama City and the Panama Canal entrance is a relatively small area in which molluscan species that are usually taken only offshore may be observed intertidally. This small area is bounded by Palo Seco, Canal Zone, on the east and Vera Cruz (Camaron), Panama, on the west, with Venado Island at its hub, a total distance of about 8 kilometers.

One or more as-yet unknown factors, in addition to the low tides, may be responsible for this phenomenon because:

(1) A large number of "offshore" species are found here intertidally.

(2) Similar zones of equally low tides occur at Farfan and Kobe Beaches within this area but rarely have "offshore" species.

(3) The "offshore" species are rarely taken on the exposed flats on the outside of Venado Island — just on the inside.

(4) The "offshore" species are sometimes taken here at plus tides when relatively little area is exposed.

The following is a partial list of the "offshore" species that have been taken in this area alive intertidally. To my knowledge none have previously been reported from the intertidal zone.

Leptopecten tumbezensis (Orbigny, 1846)
Semele junonia (Verrill, 1870)

Alora gouldii (A. Adams, 1857)
Natica grayi (Philippi, 1852)
N. idiopoma (Pilsbry & Lowe, 1932)
N. othello (Dall, 1908)
N. broderipiana (Recluz, 1844)
N. elenae (Recluz, 1844)
Ficus ventricosa (Sowerby, 1825)
Distorsio constricta (Broderip, 1833)
D. decussata (Valenciennes, 1832)
Bursa nana (Broderip & Sowerby, 1829)
Pterynotus pinniger (Broderip, 1833)
Aspella indentata (Carpenter, 1857)
Trophon carduus (Broderip, 1833)
Strombina dorsata (Sowerby, 1932)
S. turrita (Sowerby, 1832)
Latirus concentricus (Reeve, 1847)
L. mediamericanus (Hertlein & Strong, 1951)
Lyria barnesii (Gray, 1825)
Subcancilla gigantea (Reeve, 1844)
Cancellaria decussata (Sowerby, 1832)
C. gemmulata (Sowerby, 1832)
C. ventricosa (Hinds, 1843)
C. tessellata (Sowerby, 1832)
C. jayana (Keen, 1958)
C. balboae (Pilsbry, 1931)
C. mitriformis (Sowerby, 1832)
C. clavatulata (Sowerby, 1832)
C. bulbulus (Sowerby, 1832)
C. solida (Sowerby, 1832)
Conus orion (Broderip, 1833)
C. lucidus (Wood, 1828)
C. tornatus (Sowerby, 1833)
Calliclava albolaqueata (Carpenter, 1865)
Crassispira maura (Sowerby, 1834)
C. turricula (Sowerby, 1834)

SOME RESULTS OF THE NATIONAL MUSEUM OF NATURAL HISTORY—
SMITHSONIAN TROPICAL RESEARCH INSTITUTE SURVEY OF PANAMA
1971-1975

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A survey of the Pacific and Caribbean coasts of Panama that involved intertidal and shallow water collecting and included sampling of all canal locks has been conducted since 1971 to obtain an adequate and timely representation of the fauna prior to proposed construction of a sea level canal. The area has been visited at least twice a year, in spring and fall, and several additional trips were made at irregular intervals. The substantial collections of mollusks obtained have been processed at the National Museum of Natural History, and 340 species from Panama's Caribbean coast have been identified, as compared with 534 species reported by Olsson & McGinty (1958), 322 by Bayer, *et al.* (1970), and 297 by Radwin (1969) from the same general area. Specimens from the Pacific coast currently are being classified. We hope that these recently made collections, when combined with those already in the NMNH, will provide "baseline before" material for study of the fauna in the event the oceans are connected by a passageway allowing the biota to move more freely between the Pacific and Caribbean.

Virtually nothing was known of the molluscan fauna of the Panama Canal locks with the exception of the few species mentioned by Hildebrand (1939) and sporadic mention elsewhere. The Gatun Locks were surveyed in March 1974 (Rosewater, 1975). Collections were also made when the upper and lower Miraflores Locks and Pedro Miguel Lock on the Pacific end of the Canal were dewatered in August 1974 and February 1975, respectively. These have been analyzed and the data are presented in Table I.

Of the 74 species collected in the locks the numbers are considerably higher in the Miraflores complex than they are in the Gatun Locks. This appears to be correlated with the higher salinity values at Miraflores, but possibly also in part to a richer fauna in Panama Bay than in Limon Bay, the latter explanation suggested by F.M. Bayer (pers. comm.).

Two lock-occurring species live at each end of the canal in both the Miraflores and Gatun locks: *Mytilopsis sallei* (Recluz, 1849) (Dreissenidae)

Table 1

Mollusks of Panama Canal Locks

Lock	Salinity ¹	Number of Species
Miraflores		
Lower	12-30 + °/°°	59 (M-B)
Upper	1.5-6°/°°	19 (B-F)
Pedro Miguel	.1-.3°/°° (.5?)	3 (B-F)
Gatun		
Upper	.1-.3°/°°	2 (B-F)
Middle	1-2.5°/°°	4 (B-F)
Lower	5.7-14.3°/°°	10 (B-M)
		² Total = (74)

B = Brackish

F = Fresh

M = Marine

1 Salinity ranges from Jones & Dawson (1973)

2 Total number of species collected alive in locks, excepting repetitions in some locks.

and *Alexania floridana* (Pilsbry, 1945) (Epitonidae) found in the lower lock at both ends and which may be transported on fouling organisms such as anemones attached to ships.

The discovery of *Alexania floridana* in the locks was surprising. Its habitat in 21 to 24 meters of water on the floor of the locks contrasts strongly with that usually reported: high tide line among rocks. In connection with these studies *Alexania* now also is known to occur in the Gulf of California where it was discovered by M.J. Goldsmith in 1973 at Sonora, Mexico (pers. comm.). The genus *Alexania* has now been found in Florida, the Gulf of Mexico area, on each side of the Panama Canal, in the Gulf of California, in South Africa, southern India and Japan. It usually has been reported to be associated with the anemone *Aiptasiomorpha luciae* (Verrill) a cosmopolitan species (Hedgpeth, 1954; Pilsbry, 1945; Robertson & Oyama, 1958; Robertson &

Habe, 1965). *Alexania* may be confused with *Recluzia* (Janthinidae) which it resembles strongly in many shell and soft-part characters. A helpful distinguishing feature is the presence of an operculum in *Alexania* and its absence in the pelagic *Recluzia*.

Aligena cokeri Dall, 1909, is listed by Keen (1971) in the family Montacutidae and by Abbott (1974) in Lasaeidae of which the former is declared a synonym. It is a member of the large group of small clams belonging to the Superfamily Galeommatacea (Erycinacea) which often are associated with other invertebrate animals as commensals or perhaps as parasites (Boss, 1965).

When Dall described *A. cokeri* he stated that it was found attached to *Chaetopterus*-like worm tubes, the makers of which lived in the beach at Capon, Peru. The same bivalve, was found at Pilot House Beach Naos, Island, next to the Smithsonian Tropical Research Institute Laboratory on the Pacific side of Panama, attached to the tubes of the annelid, *Mesochaetopterus alipes* Monroe, 1933, by M.L. Jones.

To date all reported commensals of species of *Aligena* have been polychaetes (Boss, 1965; Gage, 1968; Harry, 1969; Table 2). The only association described in detail is that of *Aligena elevata* which was loosely attached near the lower end of the tube of the worm, *Clymenella torquata* (Leidy, 1855), and which moved around freely in that vicinity, apparently feeding on food stirred up by the burrowing activities of the worm in the sand interstices (Gage, 1968).

the animal and shell which are applied to the tube. Further observation may reveal that the clam utilizes the current in the worm's tube for its own respiration and feeding. If this is the case it is a unique association, although quite possibly similar associations are entered into by the other *Aligena* exhibiting valve furrows like those of *A. cokeri*.

Aligena cokeri seems to be distributed sparsely on the upper 10cm of the worm tubes. Clams of the family Montacutidae (or Lasaeidae) are known to brood their young within the mantle cavity (Gage, 1968), and *A. cokeri* is no exception. Young clams are attached to the outside of the worm tubes in the vicinity of adults and also elsewhere on the tubes. It is possible that they are released inside the worm tubes, find their way out of the tubes and burrow through the sand to a position on the exterior of the tube. It is also possible they leave the mantle cavity of the adult and directly attach to the worm tube without passing into the tube cavity. An examination of decalcified animals reveals 4 tracts of thickened mantle tissue, 2 on each side of the area of byssal extrusion and attachment. These correspond to the position of the edges of the dorso-ventral furrows in the valves. They appear to be capable of engorgement with the clam's body fluid thus pressing the ventral mantle tissues against the worm tube and making a tight seal for the siphons.

Table 2

Aligena - Annelid Associations

Mollusk	Annelid	Distribution
<i>Aligena cokeri</i> Dall, 1909	<i>Mesochaetopterus alipes</i> Monroe, 1933	Panamic
<i>Aligena elevata</i> (Stimpson, 1851)	<i>Clymenella torquata</i> (Leidy, 1955)	Mid-Atlantic
<i>Aligena texasiana</i> Harry, 1969	"Polychaetes"	Gulf of Mexico

Aligena cokeri is more permanently attached to the tube of *Mesochaetopterus alipes*. Close examination of the attachment site of the clam reveals a byssal attachment with a perforation through the tube on each side of that attachment. When a clam is carefully examined *in-situ* it appears that the perforations in the tube correspond to the positions of incurrent and excurrent siphonal openings on the ventral side of

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RECENT AND FOSSIL TYPHINAE OF THE NEW WORLD

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There are 53 nominal species of Recent and fossil Typhininae in the New World; of these, 33 are extinct and 20 are living. A comparison of the present distribution of the Recent species on the two sides of Panama reveals nine Caribbean and eleven Panamic species. One of the nine Caribbean species is undescribed and is now in press. Two species included in the nine known Caribbean species, *Typhinellus sowerbii* and *Typhina cleryi*, also are found in the eastern Atlantic, and *T. sowerbyi* also occurs in the Mediterranean. Thus, only seven typhine species are strictly limited to the Caribbean province.

As in other groups of mollusks, several Recent species-pairs, or cognates, can be identified on the two sides of the Panamic, and these are:

Western Atlantic	Eastern Pacific
1) <i>Tripterotyphis</i>	<i>lowei</i>
2) <i>Pterotyphis pinnatus</i>	<i>fimbriatus</i>

3) *Talityphis* *sp.* *latipennis* (Southern Caribbean)

Additional cognate-like resemblances are apparent between some recent species in the eastern Pacific and extinct western Atlantic species.

Only two of the known fossil species occur in a presently non-tropical region, the Californian *Talityphis lampada* Keen and *Laevityphis antiquus* Gabb. The remaining 31 extinct species all have been found in tropical formations of the Tertiary Caribbean Faunal Province, as defined by Woodring in 1966. In other words, no known extinct typhine species are strictly Panamic in distribution. Although there is some controversy as to the precise date of closure of the Atlantic-Pacific seaways, many workers, including Woodring, seem to think that it could not have happened before the late Pliocene or early Pleistocene (2-3 million years ago). This

observation is noteworthy in that there are three genera represented in the modern Panamic province that are not, known to be represented in the Tertiary Caribbean province. These genera, all monotypic are *Typhisopsis* (*T. coronatus*),

Haustellotyphis (*H. cumingii*), and *Cinclidotyphis* (*C. myrae*). Another genus apparently in this category is *Distichotyphis* (*D. vema*), but its abyssal habitat and its morphology suggest that it should not be compared with other typhines.

FAUNAL AFFINITIES OF THE ARCHITECTONICIDAE IN THE EASTERN PACIFIC

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The architectonicid fauna of the eastern Pacific is depauperate, only 10 living species being known in the region. The genera *Pseudomalaxis* and *Philippia* are absent. In the western Atlantic 21 living architectonicid species are known, while in the eastern Atlantic and Mediterranean there are 19 species (Merrill & Robertson, unpublished; these numbers include 5 undescribed species). In the Atlantic and Mediterranean as a whole there are 30 species because 10 occur on both sides of the Atlantic (2 of these are separable as subspecies pairs). The genera *Pseudomalaxis* and *Philippia* respectively comprise 4 and 5 Atlantic species.

The living eastern Pacific architectonicids comprise 3 non-endemic species (*Heliacis perrieri* (Rochebrune, 1881), *H. trochoides* (Deshayes, 1830); and *Architectonica nobilis* Roding, 1798), 2 endemic subspecies (*H. architae panamensis* Bartsch, 1918; and *H. caelatus planispira* Pilsbry & Lowe, 1932), and 5 endemic species [*H. bicanaliculatus* (Valenciennes, 1832); *H. mazatlanicus* Pilsbry & Lowe, 1932; *H. n. sp. aff. H. alleryi* (Monterosato, 1878); *H. radialis* (Dall, 1908); and *Discotectonica placentalis* (Hinds, 1844);.].

Judging either by identity or close conchological similarity, 6 living eastern Pacific architectonicids (*Heliacis perrieri*, *H. mazatlanicus*, *H. n. sp.*, *H. radialis*, *Architectonica nobilis*, and *Discotectonica placentalis*) have closest faunal affinities with Atlantic species. Two (*H. architae panamensis* and *H. bicanaliculatus*) have about equal Atlantic and Indo-West-Pacific affinities. *H. caelatus planispira* would have closest Indo-West-Pacific affinities were it not for the closely similar *H. stonemanae* (Maury, 1917) from Middle Miocene strata of the Dominican Republic and Panama. Only *H. trochoides* has unequivocal Indo-West-Pacific affinities.

Heliacis trochoides is here newly reported in the eastern Pacific, 1 living specimen having been

collected by Twila Bratcher at Ayangué, Ecuador, an extension of known range 4,000 mi. eastward from the Marquesas. It is doubtful whether a breeding population is established in Ecuador, the specimen possibly having originally come from Polynesia as a veliger in the equatorial countercurrent.

The other 2 non-endemic species are of geological antiquity in middle America, the stock of *Heliacis perrieri* being represented in the Upper Pliocene by *H. robertsae* Durham, 1950, and the fossil record of *Architectonica nobilis* extending back to the Lower Miocene. The shells of *A. nobilis* tend to be more darkly colored than those in the Atlantic. The only other difference so far detected between eastern Pacific and Atlantic *A. nobilis* is that in the former region protoconch size is unimodal while in the latter region it is bimodal (Pacific protoconchs accord with the larger-sized Atlantic protoconchs).

Two other lineages of architectonicids still present in the eastern Pacific have probably been in the area continuously since at least the Miocene or Pliocene. The stock of *H. caelatus* (Hinds, 1844) was represented by *H. stonemanae* (Maury, 1917) and *H. lowei* Durham, 1950 (Pleistocene, Gulf of California). The stock of *H. mazatlanicus* and *H. bisulcatus* (Orbigny, 1842), its Atlantic homologue, was represented by "*Architectonica*" *eurybis* Olsson, 1964 (Lower Miocene, Ecuador). *H. anaglyptus* Woodring, 1959 (Middle Miocene, Panama) is the only fossil architectonicid from the late Cenozoic in the region with no living homologue in middle America or the Atlantic.

The Architectonicidae are an old, slowly evolving group sometimes developing forms which are widely disjunct geographically but which are closely similar or even indistinguishable conchologically. Their zoogeography is therefore of special interest. Only *Heliacis trochoides* has recently succeeded in crossing Ekman's "East Pacific Barrier."

LIVING *CONUS* FROM THE NEW WORLD, WITH SPECIAL REFERENCE TO 'TWIN SPECIES',

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Approximately 70 living species of *Conus* occur in the New World, of which about 30 are distributed in the Panamic Marine Province, and about 40 species occur in the tropical Western Atlantic. A number of species occurring in the two provinces can be recognized as 'twin species,'

or cognate pairs. The remaining American species do not appear to have close living relatives.

The following taxa apparently represent New World cognates:

Eastern Pacific

- C. brunneus* Wood, 1828
- C. gladiator* Broderip, 1833
- C. purpurascens* Sowerby, 1833
- C. orion* Broderip, 1833
- C. virgatus* Reeve, 1849
- C. regularis* Sowerby, 1833
- C. regularis monilifer* Broderip, 1833
- C. arcuatus* Broderip & Sowerby, 1829
- C. poormani* Berry, 1968
- C. recurvus* Broderip, 1833
- C. perplexus* Sowerby, 1857

Western Atlantic

- C. regius* Gmelin, 1791
- C. mus* Hwass, 1792
- C. ermineus* Born, 1778 (= *testudinarius* Hwass, 1792)
- C. beddomei* Sowerby, 1901 (= *brasiliensis* Clench, 1942)
- C. daucus* Hwass, 1792
- C. clerii* Reeve, 1844
- C. floridanus* Gabb, 1868
- C. austini* Rehder & Abbott, 1951
- C. villegini* Fischer & Bernardi, 1857
- C. centurio* Born, 1778
- C. pygmaeus* Reeve, 1844

The following American species are strikingly similar to Old World species:

- | | |
|------------------------------------|---|
| <i>Conus aurantius</i> Hwass, 1792 | <i>C. cabritii</i> Bernardi, 1858 (New Caledonia) |
| <i>C. californicus</i> Hinds, 1844 | <i>C. africanus</i> Kiener, 1849 (West Africa) |
| <i>C. vittatus</i> Hwass, 1792 | <i>C. cumingii</i> Reeve, 1848 (Western Pacific) |
| <i>C. lucidus</i> Wood, 1828 | <i>C. boschi</i> Clover, 1972 (Muscat) |

PATTERNS OF EVOLUTION AND NICHE PARTITIONING
IN NORTH AMERICAN *CREPIDULA* (GASTROPODA: CALYPTRAEIDAE)

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Sympatric congeners present an array of interesting questions to ecologists. How do closely-related species partition the available resources? Do differences in morphology reflect species differences in niche dimensions? Why are there more congeners in some localities than in others? How can we explain the existence of

comparable yet distinct species on different coasts, often matched one for one within a genus or a family? The genus *Crepidula* is ideal for the study of such questions, for much is known of its patterns of morphology, life history, and sympatry.

The "niche" is the composite of those

elements which characterize a species' existence in its environment, and therefore is multidimensional. Usually, the ranges which a species occupies along three or four niche "axes" are sufficient to discriminate niches of closely-related species. Axes may include such factors as food size, technique of food acquisition, substrate preference, time of activity, vertical range of feeding, and horizontal living space. The axes are related to limited resources, especially food and space.

In *Crepidula*, there are five basic ecological-morphological groups (guilds) which I have delineated by multivariate analysis of species characters. Each group is composed of species whose ranges rarely overlap, but sympatry of species between groups is common. Each group contains species with similar niche dimensions. The groups are:

1. Large, convex, subtidal species which are photopositive, form stacks upon one another, and have veliger larvae — *C. fornicata*, *C. onyx*, probably *C. dilatata*.

2. Small, convex, inter- or subtidal species with no veliger stage and no stacking. The young are photopositive but not gregarious. — *C. convexa*, *C. adunca*, probably *C. rostrata*.

3. Moderate to large, concave or flat species living subtidally without stacking. They are characterized by photonegative habits, loss of shell pigment, and frequent occupation of inner surfaces of dead shells. — *C. plana*, *C. nummaria*.

4. Small to moderate, flat species with wide depth and latitudinal ranges, and which do not form stacks but live usually at low density on boulders or dead shells. — *C. dorsata*, *C. aculeata*.

5. Moderate-sized species living offshore on shells, not forming stacks. — *C. maculosa*, *C. norrisiarum*.

Additional morphological and ecological characters aid in separation. On the basis of these groups, the major habitat dimensions for *Crepidula* are: 1) type of substrate; 2) light preference; 3) depth preference; and 4) a general size factor, which is correlated with species of predators and types of larval development, hence mortality schedules and timing of development of the larvae. Size also partially dictates substrate preferences since food particle size probably is related to body size, although this is not proven

for *Crepidula*. Whether or not filter-feeding organisms are ever limited by food is also not known. It is important to note that physiological tolerances are not in themselves niche dimensions.

In warm climates, particularly Panama, there are several *Crepidula* species from each of the five guilds. Moving north to temperate areas, the numbers are reduced to one from each guild, and finally in cold climates (New England and Alaska) the guilds intermediate in adult size drop out. This indicates the importance of adult size as a niche discriminator, and shows that niche broadening occurs in cold temperate regions, where some critical resources are perhaps not great enough, or consistent enough, or temporally dispersed enough, to allow closer species packing. However, temperate zones on both coasts of America are characterized by higher numbers of individuals per species than the tropics.

There are ecological and morphological equivalents for *Crepidula* on the Atlantic and Pacific coasts of North America (and elsewhere in the world) which are not necessarily closely related, as indicated by shell features such as muscle scars and the shape of the internal septum. Convergence or parallel evolution has occurred, so that *Crepidula* fit into similar ecological roles in geographically separated but comparably-organized shallow subtidal benthic communities; that is, there is convergence of the communities as a whole.

Because of the correspondence of morphological and ecological-behavioral characters, it is possible to predict the life history patterns of some species. For example, *C. excavata* and *C. dilatata* are expected to parallel *C. fornicata* and *C. onyx*, while *C. rostrata* is expected to be analogous to *C. convexa* and *C. adunca*. One can also predict competition at least for space to occur between members of the same guild if one of the species is transported to the locality of another — hence *C. fornicata* and *C. onyx* probably could not coexist at equilibrium. Finally, the colonizing ability of a given *Crepidula* species is determined in part by whether or not its guild is represented and by the degree of species packing which already exists in the new locale. The reason *C. fornicata* has done so well in Europe and the Pacific Northwest is that there was a lack of *Crepidula* from guild number one, and a lack of organisms from other genera assuming this role, allowing *C. fornicata* to fill a void.

EASTERN PACIFIC-WESTERN ATLANTIC FAUNAL AFFINITIES
— MURICINAE AND MURICOPSINAE

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As predominantly shallow-water, tropical mollusks, the majority of the members of the muricid subfamilies Muricinae and Muricopsinae are well represented in the ranks of twin-species, or cognates, found in both the western Atlantic and eastern Pacific faunas.

Among the Muricinae the genus-groups of *Murex*, s.s., *Phyllonotus*, *Hexaplex* or *Muricanthus*, *Aspella*, *Dermomurex*, *Calotrophon*, and *Attiliosa* all have several cognates within their ranks and evolutionary patterns are especially well exemplified among certain of the lines, such as *Murex*, s.s., and *Muricanthus*.

What is more surprising are the genus-groups that are not present on one side of the Isthmus but are on the other. Thus the genus groups of *Chicoreus*, s.s., *Siratus*, and *Pterynotus* are in the Atlantic but totally lacking in the Pacific. It is

assumed that the ecologic niches that the species of these groups might have invaded were already occupied by some other line. Likewise *Paziella* is moderately common in the deeper waters of the western Atlantic but represented by a single deepwater form from the Galapagos Islands in the Pacific. In contrast, *Purpurellus* is found in the eastern Pacific and the eastern Atlantic, but is not present in the western Atlantic today, although it is present in the fossil record.

The subfamily Muricopsinae is especially noteworthy for the prepondance of cognates, virtually every species having its twin. The single exception to this is the genus-group *Homalocantha*, again found in the eastern Pacific and the eastern Atlantic but never at any time in the western Atlantic.

ABSTRACTS AND TITLES OF PAPERS PRESENTED AT JOINT MEETING

CERBERILLA MOSSLANDICA, MCDONALD & NYBAKKEN, 1975,
A NEW SPECIES OF NUDIBRANCH FROM MONTEREY BAY, CALIFORNIA,
WITH COMMENTS ON OTHER ENIGMATIC OR UNDESCRIBED SPECIES FROM CALIFORNIA.

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Abstract

During a benthic sampling program conducted in Monterey Bay, California, in 1971-1972, 112 specimens of a small eolid were collected. Later study showed that it is most closely allied to the genus *Cerberilla*. This new species, *Cerberilla mosslandica*, was found in depths of 16 to 63 meters on a mud-sand bottom.

In the laboratory *C. mosslandica* was found to burrow into the substrate and to feed upon an as-yet unidentified burrowing sea anemone. This species had been found by earlier benthic sampling programs, as evidenced by specimens in collections from Hopkins Marine Station, Pacific Grove, California.

A number of other unidentified species occur both intertidally and subtidally along the California coast, such as *Coryphella* sp., *Trinchesia* sp., *Dendrodoris* sp., and a number of porostomes and other nudibranchs which have not yet been assigned to a genus. *Coryphella* sp. and *Trinchesia* sp. are not yet identified with a species because the genera are large and each extant species must be checked to be sure that they are not already named from another part of the world. The porostomes are particularly difficult because they lack a radula or other hard structure which is taxonomically useful.

OREOHELICID LAND SNAILS OF THE SALMON RIVER VALLEY, IDAHO

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Abstract

More taxa of *Oreohelix* occur in the Salmon River Valley of Idaho near Riggins, Lucile and White Bird than in any other part of the range for the genus. Most of the species are allopatric, with clear differences in preferred niche and exposure, but in one place both *Oreohelix strigosa strigosa* (Gould, 1846) and *Oreohelix vortex* Berry, 1932, occur in the same small rock piles. Differences in shell, radula, pallial and genital structures of these two populations are used as a standard against which to measure the significance of differences between allopatric populations. If differences in shell, radula and genitalia are equal or greater than the differences found between the sympatric species, then species level differentiation is hypothesized. The ecological differences, such as shaded rock piles, small rock piles

on steep slopes, deep limestone talus, water worn stream side boulders or flood inundated talus, under boulders in flat grasslands, and deep volcanic rock talus, also serve to distinguish species.

These probably are relicts, not taxa in a phase of active speciation, and generally occur in very limited colonies. At least two taxa, *Oreohelix idahoensis idahoensis* (Newcomb, 1866) and *Oreohelix waltoni* Solem, 1975, are in clear and imminent danger of extinction due to human disturbance of their limited colonies. Recommendations for their protection have been made to the Federal Office of Endangered Species in the Department of the Interior. (Many aspects of this paper were published in *The Veliger*, vol. 17, number 1, pp. 16-30, July 1, 1975.)

ASHMUNELLAS OF THE SAN ANDRES AND ORGAN MOUNTAINS, NEW MEXICO AND FRANKLIN MOUNTAINS, TEXAS

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Abstract

In extreme western Texas and south central New Mexico are three mountain ranges, the San Andres, Organ and Franklin, listed north to south. Three species-groups of the genus *Ashmunella* (Pulmonata: Polygyridae) are represented in the mountains. On Salinas Peak, northern San Andres Mts., occurs *A. salinasensis* Vagvolgyi, a species belonging to the group of *A. rhyssa* (Dall), which is widespread in the Sierra Blanca and Sacramento Mts. to the east. *A. organensis* Pilsbry is presently restricted to the Organ Mts., but there is fossil evidence suggesting former, more widespread occurrence of an "*A. organensis* group." All other *Ashmunellas* of these mountains seem to belong to an "*A. kochi* group." The type locality of *A. k. kochi* Clapp, one of the largest *Ashmunellas*, is judged to be on Black Brushy Mt. in the southern San Andres Mts. Immediately to the north on San

Andres Peak is a smaller relative, *A. kochi sanandresensis* Vagvolgyi. At least one other, undescribed member of the *A. kochi* group occurs in the southern San Andres Mts. In the Organ Mts. occurs *A. auriculata* Vagvolgyi, a small member of the *A. kochi* group, as well as an undescribed species. Among the most highly modified of *Ashmunellas*, conchologically, is *A. pasonis* (Drake), with two subspecies occurring in the Franklin Mts., a more northern *A. p. pasonis* (Drake) and a more southern subspecies, *A. p. polygyroidea* Vagvolgyi. *A. p. pasonis* is judged to be more advanced, conchologically, *A. p. polygyroidea* more conservative. It is suggested that a propagule from the northern (*A. p. pasonis*) subspecies somehow reached the San Andres Mts., where *A. p. pasonis* also occurs in two separated areas in the central and southern part of the range.

AN OVERVIEW OF THE FAMILY CAECIDAE ON THE PACIFIC COAST OF THE AMERICAS

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Abstract

In 1850 Gray named the family Caecidae from a single genus *Caecum* Fleming, 1813. We now recognize 4 genera on the American Pacific Coast—*Caecum*; *Elephantanellum* Bartsch, 1920; *Elephantulum* Carpenter, 1857; and *Fartulum* Carpenter, 1857. The genus *Caecum* includes two subgenera, *Caecum*, s.s., and *Micranellum* Bartsch, 1920. Over 200 species of Caecidae have been named worldwide, and 56 of these are from the American Pacific Coast.

After years of uncertainty, the family Caecidae has been placed in the superfamily Rissoacea by Dr. Donald Moore in 1962, on the basis of anatomical characteristics. A chronology of the naming of Caecid species from the Eastern Pacific starts with C.B. Adams naming of 7 species of *Caecum* from Panama in 1852, five of which still appear valid. Carpenter added 17 species and 5 varieties from Mazatlan, Mexico, in 1857 and 2 more from California in 1864. (Dall renamed one of the latter in 1885 due to unavailability of Carpenter's name.)

In 1867 de Folin named 21 species from Panama. His published descriptions appear to be unavailable in most libraries, except for three species refigured with English descriptions by Tryon in 1887. Bartsch named 14 new species in 1920 from North American Pacific waters, but Dr. Tucker Abbott synonymized all but three of Bartsch's species in American Seashells, 1954.

Strong and Hertle named 2 species from Panama in 1939, and both are probably synonyms of earlier-named species. Garrell Long added a new species from the Gulf of California in 1972. From Chile one species was named by J. Stuardo in 1962, and a second was added by Louie Marinovich in 1973.

The variability of the caecid shell sculpture, especially between progressive growth stages as well as in mature shells, has resulted in many synonyms. The final total of valid Eastern Pacific species should be far less than the original 56.

The tiny animals of the Caecidae are difficult to study. They appear to feed on diatoms or other

minute organisms in sand or under rocks. They are monosexual, and their spawned eggs develop into pelagic larvae. The earliest shell growth is of coiled form similar to a vitrinellid. Then the shell straightens out into a curved tube which enlarges with growth either by gradual taper or by abrupt enlargement of the shell diameter at irregular growth periods. Both growing and mature shells show marked variations in sculpture within most

species.

A plug or septum is developed to close the posterior end of the postnuclear shell, and new plugs are developed at intervals as needed, the older portion of the shell being truncated at the position of the newer plug. The caecid operculum is of horny or corneous material, circular and multispiral, often appearing to have two or three layers.

ON SOME SPECIES OF *DISCODORIS* AND THE USE OF THE RADULA IN NUDIBRANCH TAXONOMY

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Abstract

Many taxonomic groups have turned out to be little more than size categories. In particular, species of opisthobranch mollusks have often been differentiated based on size differences of the radulae or other parts of the anatomy, only later to be synonymized because researchers collect intermediate forms.

Certain opisthobranch species have a wide range of radular variation in the number of rows of teeth and the number of teeth per half-row. Regression analyses show that these variations

indicate merely differences in size, not in taxa.

The number of teeth alone cannot be used to establish the validity of a new species. If the radular count is a criterion for separation, the relative proportion between the number of rows and the number of teeth per half-row must be considered.

The opisthobranch radula is an important taxonomic character, but it must be treated as a biological entity subject to variation, and not as the product of a typological mold.

THE ORIGIN OF FOLIATED-CALCITE SHELL MICROSTRUCTURE IN THE SUBCLASS PTERIOMORPHA (MOLLUSCA: BIVALVIA)

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Abstract

The ontogeny, taxonomic distribution, and interrelationships of the major shell microstructures present in the shells of extant and fossil Pteriomorphian bivalves suggest that the foliated calcite of extant Pectinacea, Ostreacea, and Anomiaea has evolved from simple prismatic calcite, not nacreous aragonite as suggested by others. Scanning electron microscopy of the early growth stages of prisms in these groups reveals that they are homogeneous in texture adjacent to the periostracum. At later stages, folia appear within the prisms themselves and in some groups, notably the Propeamussiidae, a lateral, ontogenetic transition occurs, with prismatic calcite giving rise to foliated calcite. The reverse trend, in which foliated calcite develops into prismatic calcite, is unknown.

A nacreous origin of foliated calcite is unlikely since there is an extensive taxonomic gap in the

distribution of the major aragonitic structures. Nacre, which is prominent in the extant Mytilacea, Pinnacea, and Pteriacea, is absent from extant groups which bear foliated calcite. When aragonitic layers other than myostraca are present in foliated shells, they are crossed lamellar. A nacreous origin is also unlikely for functional reasons. If shell strength has been important in evolution, which seems likely in view of the epifaunal habits of most members of the subclass, then foliated calcite is a poor replacement of nacre because it is inferior in all mechanical properties thus far measured.

The most likely hypothesis is that foliated calcite evolved as a functional analogue of nacre in certain groups that for some unknown reason lost the ability to secrete nacre very early in their history. The ancestors of foliated-calcite bearing groups probably had simple prismatic calcitic

outer layers and crossed-lamellar aragonitic inner layers. Foliated calcite evolved later as a middle layer derived from and underlying the prismatic structure. The foliated structure then increased in prominence until prismatic structure itself was eliminated from one or both valves, as in many of the modern Pectinacea, Ostreacea, and Anomia. As discussed elsewhere, more elaborate surface sculpture, including sharp spines and scales, can be developed from foliated structure than from prismatic, and such sculpture is of

obvious adaptive significance for epifaunal groups.

Contrary to reports that the outer shell layer in the Limacea consists of finely foliated calcite, scanning electron microscopy reveals that it has a distinctive microstructure that may have evolved separately from that of the true foliated groups.

An ongoing survey of shell microstructure in fossil Pteriomorpha thus far supports these hypothetical trends.

STRUCTURES OF RECENT CEPHALOPOD RADULAE

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Abstract

A review of published scanning electron micrographs of cephalopod radulae, together with illustrations of the radula of *Loligo plei*, *Histioteuthis dofleini*, *Vampyroteuthis infernalis*, and *Octopus briareus* permit identification of different functions for marginal plates, clear distinction between teeth and plates, and clarification of the basic number and patterns of teeth and plates in major taxonomic categories. Marginal plates may function either to erect outer marginal teeth or to support them against stress. Nautiloid cephalopods differ from coleoids in having two extra lateral teeth and two inner marginal support plates. Coleoids vary in cusp patterns on the rachidian and lateral teeth, with the teuthoids varying from possession of strong marginal plates to their complete loss. Octopods are characterized by a greatly reduced lateral tooth, a very enlarged and usually multicuspoid rachidian tooth, and massive marginal plates. *Vampyroteuthis* is unique among examined

species in having an anterior prolongation of the rachidian that provides support against stress during feeding. The conspicuous grooves present on the teeth of many cephalopods function during compaction or infolding of the teeth towards the midline of the radula. These grooves cause the outer teeth to "lock" down either on the support plates (*Nautilus*) or against the inner marginals and laterals (coleoids). When the outer marginal plates are greatly reduced or lost, the grooving on the teeth often is reduced or lost and a different pattern of tooth folding and/or erection is evolved. In some teuthoid taxa that lack marginal plates an entirely new structure is present, a marginal tooth ligament that extends from the anterior basal plate of the outer marginal tooth to either the basal membrane or the posterior part of the basal plate of the next anterior outer marginal tooth. This structure was not reported previously. (This paper was published in *The Veliger*, vol. 18, number 2, October 1, 1975.)

A REVIEW OF THE GENUS *ASPELLA* (GASTROPODA; MURICIDAE)

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Abstract

The genus *Aspella* includes some of the strangest-looking muricids. Their shells are, in general, small, white, compressed, and lack spines. On the basis of their flattened shells they were assigned by many 19th century authors to the bursid genus *Ranella*. In spite of their un-*Murex*-like appearance, they have been

assigned to the Muricidae since Dall's time on the strength of the clearly muricoid radular dentition.

Although many muricid supraspecific groups seem to intergrade with allied groups, no clear lines of demarcation being apparent, *Aspella* is a notable exception. It is well-defined and separate from virtually all muricid genera and is distinctive

in its reduced number of adult varices and flattened body whorl.

Although confused by some workers with *Favartia*, it appears that these two genera do not even belong in the same muricid subfamily. Another confusion stems from the mistaken use of *Aspella* as a genus for species properly assigned to *Dermomurex* (e.g., *D. obeliscus* and *D. paupercula*). These two genera, although closely related, are easily separated by the differences in the cross-sectional shape of the body whorl (round in *Dermomurex*, elliptical in *Aspella*) and the fewer varices in the body whorl of the latter genus.

The fossil record of *Aspella* is sparse, but it seems to first appear in the Oligocene of France. Although first appearing in the fossil record of European areas, there are no species living today throughout the eastern Atlantic proper.

Recent *Aspella* has a world-wide tropical and subtropical distribution in moderately shallow water. Although there are five nominal species

available, a problem has clouded the genus, as there appears to be no way to determine the identity of the type species, *Aspella anceps* Lamarck, 1822. The unfigured holotype has not been recognized in the Lamarckian Collection. In addition, the description, which is apparently of a beachworn specimen, would fit almost any species of *Aspella*. Fortunately, for the integrity of the genus, the generic concept would not be changed if an appeal to the ICZN were made to change the type species to one more readily recognized; the species of *Aspella* all resemble each other quite closely in characters of generic rank.

In addition to the four recognizable species of *Aspella*, I have identified seven other species that differ from each other in their sculptural details and in the microsculpture of the intritacal, the soft, flat-white, chalky layer that is a prominent feature of this group. The new species are to be described in an appendix to our book, now in press.

THE NUDIBRANCH *DENDRONOTUS FRONDOSUS*: IS IT ONE SPECIES OR FOUR?

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Abstract

The nudibranch, *Dendronotus frondosus*, is a circumboreal species which shows considerable variation in color, color pattern, and external morphology though the usual taxonomic characteristics (radula, jaws, reproductive system) are remarkably conservative. However, on the basis of observations and data obtained over a six-year period in the San Juan Islands, Washington, I am able to show that the "species" *D. frondosus* is actually comprised of three and probably four ecologically distinct populations. The four phenotypes which may be distinguished on the basis of color—red mottled, white, dark brown,

light brown—can also be distinguished ecologically primarily on the basis of prey and secondarily on the basis of habitat (substratum and water depth). The evidence for genetic isolation of these phenotypes is less convincing and, at present, is circumstantial. A series of critical laboratory experiments designed to answer specific questions about the genetic isolation of the phenotypes are suggested. Until these experiments are completed, *D. frondosus* as presently described is provisionally accepted as a valid species comprised of a number of ecologically discrete populations.

NOTES ON *FUSITRITON*

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Abstract

Although I have seen several brief notations that the marine gastropod *Fusinus oregonensis* (Redfield, 1846) is utilized by the Indians of the Pacific Northwest as food, I have been unable to substantiate this. The flavor of the flesh is not only bitter, but has a strong aftertaste of iodine,

and when placed in a frying pan emits an objectionable odor. For some reason when boiled this odor is not present. Apparently, there are no natural, intertidal predators of this snail.

In Japan I learned that in some regions *Fusitriton oregonensis* is consumed by the local

inhabitants, and in some regions they are fished and exported to major cities. However, in the extreme northern area the species is discarded because of its flavor. The less common *F. galea* Kuroda and Habe, 1961, with a milder flavor, is used more often as food, but at the present time the commercial range of this species is restricted because of pollution and overfishing.

A NEW GENUS AND SPECIES OF MONOPLACOPHORA FROM THE CONTINENTAL SHELF OF SOUTHERN CALIFORNIA

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Abstract

Several additional species of monoplacophoran limpets have been described since the original discovery by the Galathea Expedition in 1952 of the living species *Neopilina galathea* Lemke, 1957, representing a class of mollusks presumed extinct by the end of the Devonian. All of the described species and additional records have been reported from abyssal or hadal depths.

In 1965 two specimens of a limpet with a maximum length of 2.4mm were taken on rocks snagged on hook and line by a fisherman in the vicinity of the Cortez Bank, due west of San Diego, California, one at a depth of 174m, and the other at 229m. The rocks bearing the limpets were transmitted to Dr. S. Stillman Berry of Redlands, California, who removed the extremely small specimens, which had dried in place.

Because of my general interest in limpets, I borrowed the specimens and prepared a radular slide from one of them. At first I thought it represented an unknown patellacean limpet, but several months ago I realized that the radula had the monoplacophoran formula consisting of a narrow rachidian and five pairs of laterals, the fourth pair bearing a broadly fringed cutting edge. Although the animal of the first specimen

The tiny *Fusitriton midwayensis* Habe and Okutani 1968, is too small and uncommon to be considered a food item. Some specimens have been dredged in 900 + meters (500 fathoms) off a plateau on the south side of the Gorda Escarpment on the eastern end of the Mendocino Fracture Zone.

had been sacrificed for the radular preparation, the remains of the animal in the second specimen showed the typically monoplacophoran characteristics of a tightly coiled intestine visible through the shell, a velum, a posterior anus, and radiating shell muscles. The sole of the foot was evidently left on the rock upon removal, because the radular sac is exposed and no traces of the monoplacophoran gills can be found. The thin, oval shell has an anteriorly positioned apex as do all living species, but lacks all traces of the concentric or clathrate sculpture known in the other living species. On this distinction plus details of the radula to be discussed elsewhere in the formal description of the new species, a new genus is indicated.

The relatively shallow water occurrence of a living monoplacophoran is contrary to all previous expectations for the group. Of greater importance, however, is the certainty that the new form occurs attached to a hard substrate. Previously described species have not been associated with hard substrates and have been presumed capable of existing on soft substrates, a mode of life unknown in any of the limpet families within the gastropods.

THE GENUS *PILSBRYSPIRA*: ITS POSITION IN HISTORY AND THE FAMILY TURRIDAE

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Abstract

The genus *Pilsbryspira* Bartsch, 1950, (Turridae: Prosobranchia) is commonly represented in shallow, usually rocky, warm water habitats of the Eastern Pacific and the Western Atlantic.

The group probably arose in early Pliocene in the Caribbean basin from crassispire stock. Ancestral forms probably had beaded sculpture

similar to the Western Atlantic *Pilsbryspira leucocyma* (Dall, 1883) known from Florida Pliocene formations as well as the Recent. Strong spiral shell sculpture, particularly a heavy subsutural cord, appears to have developed after the separation of the Eastern Pacific and Western Atlantic faunas. Strong spiral sculpture is most

highly developed in Eastern Pacific species. Protoconch whorls are slightly fewer and first whorl diameter is greater in Western Atlantic representatives.

The buccal masses of the six species of *Pilsbryspira* examined by dissection and serial sections are crassispirine in form. They have an odontophoral cartilage, functional musculature, and a radular ribbon. Examination of the radular teeth in SEM preparations and glycerin jelly mounts show them to be modified duplex, and they are used attached to the radular ribbon

within the buccal cavity.

Species now allocated to the genus were placed in *Crassispira* subgenus *Monilispira* Bartsch & Rehder, 1939, on the basis of shell characters. They were removed from the genus and subfamily because the teeth were thought to be of the hollow, true toxoglossate type which are used singly at the tip of the oral tube (as in *Conus*). This study shows sufficient distinction to separate *Pilsbryspira* from *Crassispira* and *Monilispira*. However, the genus *Pilsbryspira* does belong in the subfamily Crassispirinae.

THE EFFECTS OF GRAZING ON ALGAE BY LIMPETS AND LITTORINES

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Abstract

The requirement for substrate heterogeneity by intertidal limpets and littorines was investigated. On sea walls located at Hood Canal, Washington, several exclusion experiments were established in April 1974. By January 1975 limpet and littorine removal areas were recolonized by diatoms and ulvoids. The algae were most

abundant in winter, followed by a summer die off. The technique of excluding habitat from *Littorina scutulata*, *L. planaxis*, *Collisella digitalis*, *C. strigatella*, and *Notoacmea persona* may enable investigations on mechanism of co-existence by these species.

THE LIFE AND TIMES OF S. STILLMAN BERRY

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Abstract

This is a resume of major events and activities in the life of S. Stillman Berry to the present time.

Ralph and Evelyn Berry, his parents, came from Unity, Maine, to a homestead on the Musselshell River in Montana in 1877 and 1878, respectively. Six years later, Evelyn returned to Unity, where, on March 16, 1887, twins were born. One of the twins survived only a few hours. The other became Dr. S. Stillman Berry.

The harsh Montana winters proved too severe for the frail baby. The mother and boy spent the next ten years traveling about, hunting for a climate which his health could tolerate. At last, they settled in Redlands, California, where he has resided in the same house since 1913.

Stillman collected his first mollusk at Point Judith, Rhode Island, when five years old. In Redlands, at thirteen, he authored his first article. The illustrated paper was published in St. Nicholas Magazine and was about a cactus wren's nest.

The years from 1905 to 1909 were spent at Stanford University. He received his Bachelor of

Arts Degree in 1909 together with keys from Phi Beta Kappa and Sigma Xi. During this time, he had been in communication with Dall at the National Museum. In 1907, Dall and Bartsch, together and separately, named three molluscan species after him.

The academic year 1909-1910 was spent at Harvard where he met all the requirements for a Master of Science Degree. In September, 1910, he returned to Stanford and was home when his father died in June, 1911. Following several years of concentrated study, Dr. S. Stillman Berry was hooded at Stanford in May, 1913. His dissertation was concerned with Cephalopods. The study of this class of mollusks has been a lifelong interest which may well prove to be his greatest scientific achievement. He had already described his first cephalopod in 1911. It is *Abraliopsis scintillans* (Berry), an important food source for the Japanese.

Summers on the ranch, which has grown to an impressive 50,000 acres, laid the foundation for a keen interest in paleozoology and conservation.

His close association with his mother, the effect of the ranch which was rich in fossil remains of several geologic ages, and an alert and inquiring mind developed a warm personality which has always attracted a wide circle of close and lifelong friends. These include people from museums and research institutions, and those with diverse interests such as hybridization of iris, geneology and stamps.

One may summarize the important things which have happened to him this way: Conchological Club of Great Britain and Ireland

(Life Member); San Diego Society of Natural History (Honorary Fellow); Smithsonian Institution (Research Associate); American Association for the Advancement of Science (Life Member, 1917); Boston Malacological Society (Charter Member); Malacological Society of London (Life Member); American Malacological Union (Honorary Life President, 1960); and a copy of the Emperor's book on the Shells of Sagame Bay was personally sent to him through Japan's Washington Embassy.

PRELIMINARY ANALYSIS OF THE LAND MOLLUSK FAUNAS OF THE ISLANDS OF SOUTHERN CALIFORNIA AND NORTHERN BAJA CALIFORNIA

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Abstract

The Channel Islands of California and the islands off the Pacific coast of northern Baja California, Mexico, support 44 species and subspecies of indigenous land mollusks. The dominant families are the Helminthoglyptidae and Pupillidae. Number of taxa per island is roughly proportional to land area and increases in an approximately logarithmic manner to the area of sampling. In comparison to the nearby mainland, the southern Channel Islands have greater faunal diversity per unit of land area. Their highest diversity may have been achieved during a Holocene low sea-level stand 14-16,000 years before present, with faunal "packing" and extinctions following a subsequent decrease in available land area.

Twenty-six, or 59.1 per cent of the native

species are strictly insular endemics, known only from one or more of the islands; seven other forms are considered subspecies of mainland species. Islands closer than 29 kilometers from shore, except Anacapa, have no insular endemic species; islands farther from the mainland show 50 to 100 per cent endemism.

The northern Channel Islands show zoogeographic relationship to coastal California to the north. The southern Channel Islands have faunal affinities to the Baja California mainland and to Guadalupe Island, with a smaller number of Californian elements. The nearshore Mexican islands show very close affinity to the adjacent mainland, while Guadalupe Island contains a mixture of geographic elements.

ORIGIN OF ASIAN "HYDROBIIDAE" IN TIME AND SPACE

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Abstract

Asian snails previously considered Hydrobiidae are of a lineage different from true European Hydrobiidae. Evidence to date indicates that the origin of the Asian taxa was in

Gondwanaland over 150 million years ago. Introduction to mainland Asia was probably via the Indian plate.

COMMENTS ON COSMOPOLITANISM

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Abstract

Many shallow-water benthic marine organisms have been referred to in the literature as being "cosmopolitan" in distribution, information of importance if we are interested in the origin of cosmopolitan species, percentage of endemic species within a province, or the distribution of a species in light of its biology and ecology.

For at least two reasons it is tempting to categorize an organism as cosmopolitan. First, it seems to many workers to be logical to infer the presence of a species between two points of collection (even if these be Alaska and San Francisco!), and lists of "inferred species" in a faunal account are common. This perhaps stems from the worry that where we find many animals reflects more the distribution of zoologists than the distribution of organisms. Second, we search for patterns in nature, and it is conceptually simpler to assign an animal, or a set of animals, to the category "cosmopolitan," than to deal with it at some lower distributional category. By making such an assignment, we set a large number of awkward, confused, fragmented, and disjunct records into an elegant, clear, whole, and continuous picture.

However, we fail to reinvestigate adequately, if at all, the nature of the records upon which world-wide occurrences have been assigned; many of these records date to the nineteenth century and predate our current concept of the

species in question. In fact, many "cosmopolitan" species are found, after analysis of those original records which are verifiable, to have disjunct and widely-separated occurrences, or to involve in fact more than one species. Moreover, species which have been transported by man around the world (synanthropic species) are also commonly but erroneously referred to as "cosmopolitan," though they most often show classical disjunct distributions, occurring in no more than 20 or 25 separate harbors in the world.

The word cosmopolitan encompasses all populations, however peripheral or disjunct, and allows no understanding of real distributional patterns, of centers of dispersal if such exist, and of other zoogeographic phenomena. I would suggest that (1) exact stations at which species have been collected be reported in statements of distribution, if these do not involve scores of localities, and if these span two or more provinces, so that such data will be amenable to precise analysis; (2) we resist copying and recopying from one work to another the ranges and distributions of species, with each transcription gaining a little more generality, but instead attempt to seek and check original sources and records; and (3) we bring into question on a taxonomic basis those species which are said to be cosmopolitan, in light of the fact that the amazingly wide distributions of some marine organisms may reflect more the marvels of taxonomy than of nature.

EVOLUTIONARY RATES IN GASTROPODS

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Abstract

Existing radiometric dates and stratigraphic correlations are sufficient to provide a reliable framework for evaluating evolutionary rates in fossil organisms. For gastropods the best available data are derived from papers that review genera areally or stratigraphically, and in which the contained species are summarized phylogenetically. Existing data mostly concerns marine species no older than Cretaceous. The time span of individual species in inferred

phylogenies (the phylogenetic span) ranges from 25 million years/species to 0.5 million years/species, with a mean value of 5 million years/species. Phylogenetic spans tend to decrease from the Permian to the Cenozoic, suggesting increasing rate of speciation. Mean phylogenetic span is a measure of the average rate of evolutionary turnover of gastropod diversity through time. Total potential taxonomic diversity of easily fossilizable gastropods since

the beginning of the Cambrian Period can be calculated using this mean rate of change, the total time span, the present species diversity and the temporal pattern of changing diversity. Time span is 600 million years. Present diversity of easily fossilizable gastropods is estimated at 30,000 species. Pre-Cretaceous diversity was much lower and increased sharply in the Early Cretaceous; the curve of changing diversity is of exponential form. Calculated total potential taxonomic diversity is approximately 600,000

species, possibly only two-thirds of which are likely to be preserved. Living and fossil gastropods already described number about 45,000, or 10 percent of the potentially knowable gastropod species. Additional calculations using high and low values for phylogenetic rate and varied estimates of living and pre-Holocene diversity do not affect the major conclusion: The great majority of gastropod species have yet to be described.

EVOLUTIONARY RELATIONSHIPS BETWEEN THE THREE ORDERS OF THE PROSOBRANCH GASTROPODS

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Abstract

The relationships between the three prosobranch gastropod orders is questioned. It is unlikely that Mesogastropoda and Neogastropoda have evolved from Archeogastropoda due to differences in kidney position. Twenty-four of the

twenty-six characters used to distinguish Neogastropoda occur in Mesogastropoda. The remaining two, while different, are believed to derive from Mesogastropod characters.

BODY SIZE DISPERSAL AND THE ORIGIN OF THE PACIFIC LAND SNAIL FAUNA

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Abstract

Minute and very small land snails, whose shell is below 21mm in size, are significantly more frequent in the Pacific land snail fauna than in continental ones. This supports the interpretation

that most Pacific land snails reached their present area of distribution through aerial dispersal, winds and birds.

FUNCTIONAL MORPHOLOGY OF FEEDING IN THE PREDATORY WHELK, *ACANTHINA SPIRATA* (GASTROPODA: PROSOBRANCHIA)

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Abstract

Acanthina spirata may be found in the rocky intertidal zone from Tomales Bay California to Camalu, Baja, California. Most commonly it is in association with a variety of sessile barnacles upon which it preys, but also among the tubes of annelids and vermetid gastropods, mussels, and aggregating anemones where it finds shelter.

The anatomy of the anterior portion of the animal is similar to that described for *Urosalpinx cinerea* by Carriker in 1943 and for *Thais* (*Nucella*)

lamellosa by Fretter & Graham in 1962. Paired odontophoral cartilages support a typical quinquicuspoid rachidian radula with scythe-like marginal teeth. The buccal mass and "palate" are protected by a cuticle. The receding radula nestles into the sublingual epithelium where it is probably dissolved. The pharynx opens dorsally from the buccal cavity, passes posteriorly to bend anteriorly over the ventral surface of the invaginated proboscis, again passes posteriorly

through the cephalopodal ganglion and posterodorsally through the mass of the Gland of Leiblein. Anterior to the ganglion, a pair of acinous salivary glands direct their contents through ducts which parallel the pharynx, to empty in the dorsolateral buccal cavity. A pair of simple tubular accessory salivary glands originate in the cephalic hemocoel ventral to the salivary glands. Their ducts join as they enter the proboscis. This common accessory salivary gland duct empties very anteriorly in the mouth. Just posterior to the transverse groove of the propodium, is the boring gland (Accessory Boring Organ).

Predation upon bivalves involves dissolution of the valve at a suitable site on its margin by a

secretion of the boring gland, the boring gland remaining in contact with the shell for periods of 1.5 to 5 minutes. The softened matrix is then removed by radular rasping. Approximately 8 to 20 teeth are used at each rasping stroke. In the laboratory the relatively thin margin of a mussel shell may be penetrated in much less than a day.

The wheel feeds upon mussel tissue by extending the proboscis through the bored hole and rasping the softer tissues with the radula. Swallowing seems to involve suction as well as retraction of the buccal mass. Each stroke of less than a second's duration results in a bolus of flesh so that two or three boli may be seen at once in the transparent pharynx. Gregarious feeding upon mussels is frequent.

METAL AND PESTICIDE CONTAMINATION AND CONCENTRATION IN THE MOLLUSCS OF THE LAKE TAHOE BASIN

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Abstract

Gross tissue lead levels in some mollusks of Lake Tahoe Basin localities have increased by factors of 1.1 to 2.0 from 1970 to 1975. Levels of DDT in the tissues of these mollusks have increased by factors of 1.4 to 3.1 in different localities. Gametogenesis in *Pisidium casertanum* Poli, a sphaeriid clam, was shown to be disrupted at low levels of lead and DDT concentration. Gametocyte maturation may slow or stop, with the introduction of these pollutants. Laboratory investigations have established a 50% reduction of mature gamete production in this monoecious species at lead concentrations of 2 PPM and DDT concentrations of 20 PPM. Yearly clam samples (1970-1975) from Sage Hen Creek, Alder Creek, Prosser Creek, Dam, Tahoe City (Truckee River and near-by trout research facility), Eagle Lake, and the El Dorado

National Forest Visitor's Center showed gross tissue lead levels ranging from .4 to 1.6 PPM. Specimens of *Pisidium* from these localities showed gross tissue DDT levels of 1.1 to 16.1 PPM. Populations of this clam at the outlet of Lake Tahoe (The Truckee River at Tahoe City) and at the Visitor's Center showed numerical declines of 22% and 25% respectively during the 1973 season, the peak period of DDT concentration in soft tissues. An occasional clam predator, the leech *Glossiphonia* sp. at the Prosser Creek Dam locality proved to have 8.1 times the average tissue DDT concentration of its prey, *Pisidium*. This partial chain biological magnification of a toxic substance is significant when considering the fish and bird populations of the Lake Tahoe Basin.

EXTINCT AND ENDANGERED POPULATIONS OF THE ENDEMIC MUDSNAIL *CERITHIDEA CALIFORNICA* IN NORTHERN CALIFORNIA

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Abstract

The northernmost Eastern Pacific populations of the potamidid *Cerithidea californica* (Haldeman 1840) were confined to a five-bay system in central California: Bodega Harbor, Tomales Bay,

Drakes Estero, Bolinas Lagoon, and San Francisco Bay. The Bodega Harbor population appears to have become extinct about 1963 due to road construction, leaving the northernmost

populations of *Cerithidea* in at least two stations in southern Tomales Bay, Inverness and Millerton.

Examination of a few fragmentary nineteenth century literature records and of museum specimens from the 1870s to the 1940s reveals that *Cerithidea* was once widespread and common throughout San Francisco Bay. Today, *Cerithidea* is apparently restricted to a few small populations

at the southern tip of the San Francisco Bay estuary. Its near demise in the bay may be most strongly related to habitat destruction through the filling of *Salicornia* salt marshes and higher intertidal mudflats since the 1850s. The influence of the introduction of the Western Atlantic estuarine mudsnail *Ilyanassa obsoleta* about 1900, which maintains extremely large populations in the bay, remains to be investigated.

ANOTHER CHECK-LIST PLAN?

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Abstract

The need for a comprehensive American check list has been felt for some time. As early as 1936 proposals for a committee on check lists were put before the AMU's executive council, and in 1937 such a committee was appointed. In 1940 its chairman resigned and a new one was appointed. As this committee was never afterward called upon for a report, the project lapsed, although in 1947 one of the papers given in the Pacific Division meeting was a fresh plea for a list. One

must conclude that appointed committees are not sufficiently motivated to get the job done. Perhaps this sort of list can better be attempted by volunteer workers who agree to take units within their competence and jointly, to put together something that no one worker could hope to complete. Such a committee of volunteers is already laying plans for a West Coast list. Will it succeed?

PRELIMINARY OBSERVATIONS ON *RABDOTUS* IN BAJA CALIFORNIA

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Abstract

Approximately thirty species of the land snail genus *Rabdotus* Albers (Pulmonata: Bulimulidae) occur in Baja California, Mexico, and on nearby islands in the Gulf of California. We are preparing a taxonomic revision of these species. Results from study of genital anatomy and shell morphology indicate the necessity of certain changes in the assignment of species to subgenera now defined on the basis of shell characters alone. *Rabdotus*, s. s., contains species having globose or ovate shells, a simple peristome, not expanded or reflected. The vagina and penis are short, the epiphallus long (about half the combined length of the penis, epiphallus, and epiphallic caecum). The subgenus *Plicolumna* Cooper contains species with elongate or turritid shells, angulate or keeled nuclear whorls, and a simple or somewhat expanded peristome.

The genitalia are similar to those of *Rabdotus*, s.s.; the penis and vagina are short, the epiphallus relatively long (one-third to one-half the combined length of the penis, epiphallus, and epiphallic caecum). In some species the mantle bears darkly pigmented markings, a feature not found in other Baja California *Rabdotus*. The third subgenus, *Leptobyrsus* Crosse & Fischer, contains species having oblong shells with rounded nuclear whorls and an expanded or reflected peristome. The genitalia are characterized by a long vagina and long penis (over half the combined length of the penis, epiphallus, and epiphallic caecum) and a short epiphallus. We include as a synonym of *Leptobyrsus* the subgenus *Puritanina* Jacobson and probably also the subgenus *Hannarabdotus* Emerson & Jacobson. The shell characters used to

distinguish these taxa from *Leptobysrus* are unreliable and may vary within a single species or between species which appear on anatomical grounds to be closely related. The type species of

Leptobysrus and *Puritanina* are indistinguishable anatomically. The type species of *Hannarabdodus* has not yet been dissected.

THE INTRODUCTION OF GIEMSA AND CENTROMERIC BANDING TECHNIQUES OF CHROMOSOMES TO MOLLUSCAN CYTOTAXONOMY

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Abstract

Chromosome banding techniques in the past six years have revolutionized the science of cytogenetics in general and the study of karyotypes in particular, rendering the classical methods of homologous chromosome identification almost obsolete overnight. Subjecting mitotic metaphase chromosome spreads to banding techniques results in banded chromosomes. The number and position of chromosomal bands is unique and reproducible for each homologous chromosome pair in the diploid set. Chromosome banding, therefore, greatly facilitates identification of homologous chromosome pairs, construction of karyotypes, identification of chromosomal aberrations and variations within or between species populations. These techniques were essentially developed by mammalian cytogeneticists over the past six years, and as a result, have achieved fine resolution by the human cytogeneticists.

The present study is an attempt to use these new techniques for molluscan cytotaxonomy. Snail ovotestes were found to be of little value for consistent and large numbers of mitotic chromosome spreads. Thus, we used snail embryos to overcome this obstacle.

Embryos of *Bradybaena similaris* (Bradybaenidae), *Helix aspersa* (Helicidae), *Discus cronkhetei* (Endodontidae), and *Rumina decollata* (Achatinellidae) were used for this study. The only exception was ovotestes squashes of *Sonorella simmonsii* (Helminthoglyptidae).

Embryos with diameters of 0.5-1.0 mm yielded a maximum number of mitotic chromosome spreads. The snail egg capsules were broken in a colchicine (10^{-4} M) hypotonic citrate (0.5%

sodium citrate) solution under the dissection microscope to free the embryos from the surrounding albumin. The embryos were incubated in fresh colchicine hypotonic citrate solution for 30-40 minutes at room temperature; fixed in methanol-acetic acid (3:1) for 30 minutes; and transferred to 45% acetic acid for 15 minutes. One embryo was squashed on a drop of 45% acetic acid under a coverslip. The entire batch of slides, thus prepared, was frozen in dry ice and the coverslips removed with a sharp razor blade. For the Giemsa (G) banding the "ASG technique" of Sumner, *et al.*, 1972 (Nature New Biol., 232:31-32) was used, and for centromeric (C) banding the "BSG technique" of Sumner, 1972 (Exptl. Cell Res., 75:304) was applied. In successful preparations chromosomes with Giemsa bands can be easily karyotyped. Karyotypes of *Bradybaena similaris* and *Discus cronkhetei* were prepared from "G" banded chromosome spreads. A comparison of 12 mitotic chromosome spreads of *B. similaris* from 12 embryos indicated heteromorphism in the length of the largest metacentric and telocentric chromosome pairs.

The "C" banding technique was used on mitotic spreads from embryos of *B. similaris* and ovotestes squashes of *Sonorella simmonsii*. The constitutive heterochromatin around the centromeres of *B. similaris* chromosomes is relatively small in amount when compared to human or mammalian chromosomes. The same can be inferred from the interphase nuclei of the ovotestes of *S. simmonsii*. Thus, "G" and "C" banding techniques may prove to be two new tools in molluscan cytotaxonomy.

ABUNDANCE, DIVERSITY AND TEMPORAL VARIABILITY OF AN INTERTIDAL NUDIBRANCH POPULATION

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Abstract

A three-year study of nudibranch populations on Asilomar State Beach, California, indicated dominance was shared among 9 species which comprised 87% of the total number of individuals enumerated. The average number of species found per month was 13, but a species-area plot indicated that 28-29 species was the maximum number which could be expected. Species diversity (H) varied over months and years, but the variation was not significantly different among months such that the average diversity

($H=1.82$) can be considered a measure of the diversity of the system. Diversity was found to correlate most highly with species number and less with number of individuals. Fluctuations in numbers of individuals and numbers of species among months and years was not different than that expected by chance except for one month. Hence the population structure appears stable in time. There was no evidence of sudden appearances and disappearances of species.

SCUBA ASSISTED STUDIES OF FRESHWATER SNAILS

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Abstract

In early August, 1974, SCUBA was used to study the depth-distribution of the snails of New Mission Bay, a small inlet of Grand Traverse Bay, Lake Michigan. Five 0.5m^2 samples were collected 6.1m apart along each of six depth contours at two locations (1.5, 3, 4.6, 6.1, 7.6, 9.1m and 3, 3.8, 4.6, 6.1, 7.6, 9.1m, respectively). Three species dominated the benthic molluscan community. *Gyraulus parvus* (Say) reached peak mean densities of $2.4/\text{m}^2$ and $28.4/\text{m}^2$ at 10 ft depths in both locations. These densities represent 60% and 92% of the specimens of *G. parvus* collected from the two localities. Most specimens of *G. parvus* were collected from small pebbles. Both *Marstonia decepta* (Baker) (= *Ammicola lustrica* Pilsbry) and *Valvata tricarinata* (Say) attained their highest mean densities at the 10 ft depth ($164.8/\text{m}^2$ and $29.6/\text{m}^2$, respectively) of one locality, and the 12.5 ft depth ($152.4/\text{m}^2$ and $49.2/\text{m}^2$, respectively) of the other. These densities represent 60% and 54% of the *M. decepta* and 37% and 30% of the *V. tricarinata* specimens collected from the two localities. Most *M. decepta* and *V. tricarinata* were collected from sand-silt substrates. Continuing work will attempt to verify and explain these distributions in these and other localities.

Late in September, 1974, three 0.1m^2 samples were collected at each of seven meanders and seven reaches alternating along Runyan Creek, Livingston Co., Michigan. The molluscan community was composed almost entirely of

Viviparus georgianus Lea (= *V. contectoides* [Binney]). Densities averaged $520/\text{m}^2$ and reached a maximum of $864/\text{m}^2$. Four of the meander stations and four of the reach stations showed sex ratios significantly ($p<0.001$) different from 1.0. The mean female/male density ratios were 1.5 for reach stations and 1.3 for meander stations. There was no discernible pattern among populations which contained equal as opposed to unequal numbers of females and males. Data were subjected to a computerized three-factor analysis of variance test to determine the individual and simultaneous effects of the following three factors on wet body weight: gender, stream position, and station type (meander or reach). Females were significantly ($p<0.001$) heavier than males with an average female/male weight ratio of 1.8. Weights also varied significantly with stream position ($p<0.001$) (females larger downstream) and type (meander or reach) of station ($p<0.05>0.02$) (no pattern). Differences between female and male weights were significantly ($p<0.05>0.02$) effected by stream position (greater downstream) but not by station type. Also, the weight differences among the stations were significantly ($p<0.001$) effected by station type (no pattern). Furthermore, there was a positive interaction among all three factors effecting weight ($p<0.02>0.01$). Continuing work will attempt to explain the bases of these interactions.

THE EFFECTS OF THE REPRODUCTIVE CYCLE ON SEASONAL GROWTH
TRENDS IN THE OWL LIMPET, *LOTTIA GIGANTEA*

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Abstract

Growth and reproduction of *Lottia gigantea* (Gray), the owl limpet, were studied for a one-year period at a location in Baja California Norte.

Through histological analysis of gonadal tissue, *Lottia* was found to spawn once annually. Spawning occurred during February 1974 and was followed by a brief resting phase with gonad redevelopment recommencing during the summer months. Several "simultaneous" hermaphrodites were found among the monthly samples. Females dominated the larger size classes of mature individuals, while the smaller size classes were predominantly male. Age at first reproduction was calculated as 3 years.

By monthly measurement of marked individuals, seasonal growth patterns were established. Periods of shell growth and gonad development were mutually exclusive, the former occurring in all size classes only in the spring months after the cessation of spawning. Small (nonreproductive) individuals, however, were found to grow on a limited basis throughout the year.

Although highly variable, annual growth data conformed reasonably well to the Brody-von Bertalanffy model and were treated accordingly ($k = .1775$). Annual growth rate appeared to be affected by tidal position and possibly by sex.

AN ANALYSIS OF FEEDING OF TWO SPECIES
OF BENTHIC OPISTHOBRANCHS

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Abstract

Acteocina culcitella and *Cylichna attonsa*, two cephalaspidean opisthobranchs, co-occur at ten benthic stations in northern Monterey Bay, California. These stations ranged in depth from 16 to 63 meters and were sampled quarterly during a 1½ year period using a Smith-McIntyre grab. Both species exhibited similar patterns of population abundance, and both are known to burrow into the substrate in search of food. Gut content analysis of snails from three stations showed that *Acteocina* (240 specimens) had ingested numerous foraminifera (representing 13 genera) and many sediment particles, along with small numbers of ostracods, juvenile bivalves, and polychaete worms. Analysis of 330 specimens of *Cylichna* showed that they too had

ingested foraminifera and sediment particles, but the foraminifera, with three exceptions, were all of the same genus, *Nonionella* (*N. basispinata* and *N. stella*). No recognizable remains of other organisms were found. Sediment cores taken at each station allowed comparison of the foraminifera ingested by the snails with those available in the substrate. Living foraminifera were found within the top three centimeters of substrate, and different foraminiferal species were not vertically stratified but were well integrated. Anatomical studies demonstrated differences in radula formulae and gizzard plate configuration, and these may partially explain the differences in prey items selected by these species.

THE HOMING DEPRESSION OF THE LIMPET, *COLLISELLA SCABRA* (GOULD, 1846)

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Abstract

The acmaeid, *Collisella scabra* (Gould, 1846), erodes a complex home scar on the shells of *Mytilus californianus* Conrad, 1837 and *Lottia*

gigantea (Sowerby, 1843) by radular action. The home scar is composed of two distinct depressions; the outer depression corresponds to the

limpet's shell margin, and the inner, deeper depression to the foot dimensions of the limpet. The home scar insures a tight, desiccation-resistant seal between the limpet and the substrate and may aid in resistance to wave action and predation.

Erosion of the home scar occurs as a separate activity not associated with feeding and the feeding range of the limpet appears to be

restricted to its specific molluscan substrate.

Collisella digitalis (Rathke, 1833) also erodes a dual depression home scar on *Lottia gigantea* and a flat surface on the barnacle, *Pollicipies polymerus* Sowerby, 1833.

Two exotic acmaeids, *Patelloida nigrosulcata* (Reeve, 1855) and *Scurria parasitica* form *coffea* (Orbigny, 1841) also erode complex home scars on their respective molluscan substrates.

THE VERDESIA PROVINCE: A NEW WEST AFRICAN MARINE MOLLUSCAN FAUNAL PROVINCE

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Abstract

Based upon detailed taxonomic and distributional analyses of major intertidal mollusk families, a new marine molluscan faunal province has been proven to exist on the west coast of Africa. The new province ranges from approximately 9°N latitude to 18°N latitude, encompassing the coastal regions of Senegal, Gambia, Guinea-Bissau, Guinea, and the Cape Verde Islands. I propose the name "Verdesian Province" for this zoogeographic unit in reference

to the Cape Verde Peninsula, its apparent faunistic center. On a north-south gradient running along the West African coast, the Verdesian Province occupies a mid-way position between the Mauretanian and Guinean Provinces. Large percentages of species in several of the major intertidal mollusk families analyzed were found to be endemic to the Verdesian Province: 56% in the Conidae, 50% in the Cypraeidae, 60% in the Marginellidae, and 20% in the Volutidae.

RELICT MUSSELS FROM TWO CONTINENTS

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Abstract

The *Margaritifera* of the "Pine Barrens" of south central Alabama are relict populations, living far south of the usual habitat of the family. Search for their relatives proved that *Gibbosula* Simpson 1900 from North Vietnam is a parallel relict with the same characters that is now known to belong to the same family (*Margaritiferidae*).

Another relict from this same Alabama region is *Pseudodontoideus*, which may be closer to *Unie* of Europe than any other mussel known from United States waters. The full story of these relict species will be published in a future issue of *Sterkiana*.

THE NAIAD MOLLUSKS OF THE ROCKCASTLE RIVER OF THE CUMBERLAND PLATEAU OF EASTERN KENTUCKY (BIVALVIA: UNIONOIDAE)

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Abstract

A series of 28 sites in the Rockcastle River system have been studied over the past 14 years. These collections, combined with literature records, reveal the presence of 29 naiad species. The maximum diversity, 28 species, occurs at

Livingston, Kentucky, about midway in the 53 mile length of the river. A review of records for the Livingston site since 1904 indicates a fauna decreasing in both diversity and numbers.

KARYOTYPE STUDIES IN *ASHMUNELLA* (PULMONATA: POLYGYRIDAE)

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Abstract

Land snails of the genus *Ashmunella* living in southeastern Arizona currently present a confusing taxonomic picture. The parallel evolution of shell type in numerous populations, both within and among isolated mountain ranges, has made determination of species a difficult task. Furthermore, the reproductive anatomy is also of little use in species discrimination. Species of the Huachuca Range have both divisions of the bipartite penis equal in size, while species of the Chiricahua Range have the upper sac narrower than the lower. Among the species of each range there is little variation other than size.

Because of the difficulty with using shell morphology and reproductive anatomy, we began karyotype studies of the Arizona *Ashmunella*. All species thus far investigated have a haploid number of 29, thus members alone are of no value. Karyotypes of five species are presented here. The chromosome nomenclature is after

Levan, *et al.* (1964, *Hereditas* 52: 201-220).

The karyotype of *Ashmunella levettei* (Bland) of the Huachuca Mountains consists of 5 *M*, 19 *m*, 3 *sm*, and 2 *st* chromosome pairs. *Ashmunella mogollonensis* Pilsbry of the Blue Mountains has 5 *M*, 16 *m*, 5 *sm*, and 3 *st* pairs. Of the remaining species, all from the Chiricahua Mountains, *A. esuritor* Pilsbry has 5 *M* and 24 *m* pairs; *A. angulata* Pilsbry has 5 *M*, 19 *m*, and 5 *sm* pairs; and *A. lenticula* Gregg has 5 *M*, 13 *m*, and 10 *sm* pairs, and one *st* pair.

Although, at this point, the evidence is inconclusive as to the overall value of karyotypes as a taxonomic tool in *Ashmunella*, we have found them useful in the species examined. We have also established a generic karyotype pattern for *Ashmunella* which, hopefully, will prove useful in comparison with patterns of other polygyrid genera when such patterns become available.

THE AVAILABILITY OF TAXA PROPOSED IN THE
MINUTES OF THE CONCHOLOGICAL CLUB OF SOUTHERN CALIFORNIA

Eugene V. Coan
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Golden Gate Park, San Francisco, California 94118

Abstract

The new molluscan taxa first proposed in the *Minutes of the Conchological Club of Southern California* are available for taxonomic use and must be taken into account. The *Minutes* were mimeographed, but the *International Code of Zoological Nomenclature* recommends against but does not forbid this means of reproduction. While the *Minutes* were not available for formal subscription, they were available to the public for free (or later for a minimum "assessment"), and they were widely distributed to malacological research institutions. The first few taxa proposed in the *Minutes* were advanced in a tentative fashion, but these have been accepted in molluscan literature and were republished by Burch less than a year later in unambiguous form;

little would be gained by not accepting them from their first appearances.

Altogether 29 new taxa were proposed in the *Minutes* by John Q. Burch, Thomas A. Burch, Wesley Coe, A. Hyatt Verrill, A.M. Strong (posthumously), and Robert Talmadge. Almost all were illustrated, and the type specimens of all the West American taxa are in recognized type collections. A number of the taxa from the *Minutes* will prove to be synonyms. Moreover, this form of publication is not a desirable means of advancing new taxa, and it is to be hoped that the publication of new taxa and taxonomic innovations will continue to be confined to a few, properly edited scientific journals.

KARYOTYPIC COMPARISON BETWEEN HELMINTHOGLYPTIDAE AND BRADYBAENIDAE (GASTROPODA: PULMONATA)

Noorullah Babrakzai and Walter B. Miller
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Tucson, Arizona 85721

Abstract

Members of the Old World pulmonate family Bradybaenidae have been considered by many workers to be very close relatives of the New World Helminthoglyptidae based on morphology of the shell and genital anatomy. The chromosome numbers in the two families are also comparable: $n=28-29$ in Bradybaenidae and $n=29-30$ in Helminthoglyptidae. However, chromosome numbers alone shed little light on the relationship between the two families.

One of us (W.B.M.) collected specimens of *Bradybaena similis* in July, 1974, from Hawaii. For the description of a karyotype the nomenclature of chromosomes proposed by Levan, et al., 1964 (*Hereditas* 52:201-220), has been adopted. The karyotypes of *Sonorelix*, *Greggelix* and *Helminthoglypta* (Helminthoglyptidae) are compared to that of *B. similis*.

The karyotype of *Sonorelix borregoensis* ($n=29$, $2n=58$) has 13 *m*, 15 *sm*, and one pair of *t* chromosomes. *Greggelix indigena* ($n=29$, $2n=58$) has 16 *m*, 10 *sm*, and 3 *st* pairs of chromosomes. *Helminthoglypta* cf. *H. lowei* ($n=30$, $2n=60$) has 17 *m*, 10 *sm*, and 3 *st* pairs of chromosomes.

The karyotypes of the Bradybaenid species *B. similis* ($n=28$, $2n=56$) has 2 *m*, and 26 pairs of *t* chromosomes. This is in distinct contrast to the three karyotypes of Helminthoglyptidae. While all the species of Helminthoglyptidae (14 species belonging to 9 genera) have a majority of metacentric (*m*) or submetacentric (*sm*) chromosomes, the reverse is true for *B. similis*, where the majority of chromosomes are telocentric.

The karyotypes of Helminthoglyptid species,

while differing among each other by 2-4 chromosome types, generally have the same overall pattern. This observation alone necessitates further cytological study in Bradybaenidae to determine if a karyotype with a majority of *t* chromosomes is the rule or an isolated occurrence in *B. similis*.

If other species of Bradybaenidae have similar karyotypes, then there is a significant cytological difference between the two otherwise seemingly related families. Similarly, if we assume that the Helminthoglyptids evolved from the Bradybaenids and the karyotype of *B. similis* is a "representative" one for the family, then one must assume that the ancestral Helminthoglyptid had a majority of telocentric chromosomes. Subsequently, evolution of Helminthoglyptids was followed by the change from telocentric chromosomes to metacentric and submetacentric chromosomes. The most likely mechanisms for such changes are homozygous pericentric inversions and not centric fissions. This is because centric fissions would almost double the haploid chromosome number, i.e., $n=50$ or more, which is not observed in any Helminthoglyptid studied so far.

On the other hand if the ancestral stock had a majority of metacentric and submetacentric chromosomes, retained by Helminthoglyptids, then the karyotypes of Bradybaenids further evolved by more than 25 homozygous pericentric inversions converting metacentric or submetacentric chromosomes into telocentric chromosomes. At any rate *B. similis* is cytologically different from Helminthoglyptids.

SPONDYLUS: THE RED SHELL

Glenn A. Long
The Baltimore Museum of Art, Baltimore, Maryland 21218

Abstract

We deal here with color, the color red, and one particular source of that color -- the marine pelecypod genus *Spondylus*, most notably, *S. princeps*.

Invariably *Spondylus* is identified as status material among the goods traded by aboriginal

peoples of the New World. Our attention is focused here on the sort of object *Spondylus* was when it reached the market place and how it was used in ancient times. Was *Spondylus* valued as shell, or as a source of red pigment for personal and ceremonial use?

Evidence presented from ethnological and archaeological sources supports the notion that traders and consumer peoples in the New World exchanged *Spondylus* as a raw material of a

specific color for use in objects of personal adornment, as visible indicators of accumulated wealth and as sacraments for ritual offering.

THE IMPACT OF MOLLUSCS FEEDING ON SOME WEST INDIAN GORGONIANS

Christopher L. Kitting,
Hopkins Marine Station, Stanford University
Pacific Grove, California 94025

Abstract

A 400 m² area containing 110 gorgonian colonies was observed repeatedly during February and March, 1975, on a patch reef at St. Croix, U.S. Virgin Islands. Ninety per cent of the colonies were sea fans, *Gorgonia ventalina*. Twenty per cent of these demonstrated wounds from mollusks. For all 5 mollusk species found on the gorgonians, time-lapse underwater photographs documented the progressive damage and subsequent regeneration of the prey colonies. Two *Simnialena marferula* (= *Neosimnia acicularis*) and 1 unidentified nudibranch each browsed only on sea fan polyps. Rapid polyp regeneration prevented an observable wound on the fans. Groups of 6 to 20 *Coralliophila caribaea* on the bases of 3 of the sea fans maintained a localized area on the colonies stripped of living tissue. Sample specimens defecated gorgonian spicules, but this species possibly feeds on other prey as

well. The common *Cyphoma gibbosum* usually consumed only a small area of sea fan tissue before leaving a colony. The coenenchyme could regenerate within 1 month. However, these snails removed extensive tissue from a sea whip, *Plexaurella*. After such damage, colony regeneration did not occur. The 2 *Cyphoma signatum* which were present remained on a *Plexaurella* colony, where each localized wound could regenerate largely within 2 weeks. Thus, the impact of molluscan predators ranges from browsing to extensive tissue removal. Prey regeneration occurs only where damaged is localized, and where algae do not establish themselves on the exposed gorgonian skeleton. Restricting predation to localized damage apparently conserves the existing prey colonies and may prevent "tracking" by any visual predators on the mollusks.

PAPERS PRESENTED; ABSTRACTS NOT AVAILABLE

Sphon, Gale G.--Department of Invertebrate Zoology, Los Angeles County Museum of Natural History. "The Mitridae of the Galapagos".

Berry, S. Stillman--1145 W. Highland Ave., Redlands, CA. 92373. "Thoughts on *Ocythoe*".

Abbott, R. Tucker--Delaware Museum of Natural History, Box 3937, Greenville, DE. 19807.

"American Seashells--Supplement and Third Edition".

Talmadge, Robert R.--College of the Redwoods, Eureka, CA. 95501. "Northern California Paleontological Sites".

Bailey, Joshua L., Jr.--Department of Marine Invertebrates, San Diego Natural History Museum. "Recollections of William Healey Dall, Based on Correspondence".

AMU ANNUAL REPORTS

AMU ANNUAL BUSINESS MEETING, JUNE 25, 1975, SAN DIEGO

The General Business Meeting was called to order by President Donald R. Moore at 3:30 p.m. Wednesday, June 25, 1975, in Aztec Hall, San Diego State University, San Diego, California.

Minutes of the 1974 business meeting as published in the 1974 Bulletin were approved.

The report from the Recording Secretary was approved. (Published below)

The report from the Treasurer was approved as read. (Published below) Treasurer Myra Taylor reported to members that the addition to the Dues Notice in 1974 of a space for donations to AMU met some acceptance and appreciation for such money for the treasury was acknowledged. She also urged members to send in changes of addresses to help save on postage to redirect mail.

President Moore summarized the report from the Corresponding Secretary. Approved. (Published below)

The increased value of the Bulletin to malacologists everywhere was remarked by President Moore as he announced the resignation of Dr. Arthur Clarke as Publications Editor and reported the Council's recognition of the outstanding job done by Dr. Clarke. A vote of thanks from general membership was taken at this time to express appreciation to Dr. Clarke.

A report from the budget committee was deferred until after the discussion of dues.

The nominating committee report was read as follows:

President.....	D.S. Franzen
President-Elect.....	George Davis
Vice-President.....	Henry Russell
Recording Secretary.....	Connie Boone
Treasurer.....	Myra Taylor
Councilor-at-Large.....	Herb Athearn
Councilors-at-Large.....	Hugh Porter
	Carol Lalli
Publications Editor.....	Dee Dundee

The election of Recording Secretary is for the remaining one year term of a three year term due to resignation of the former secretary, the election of Athearn for one year to fill vacancy left by moving Boone to secretary. Lalli and Porter are elected for two years. Chairman, Dr. Harold Murray; Dr. Dee Dundee, Dr. Bill Clench, and Dr.

Dave Stansbery, committee members. Slate approved.

It was announced that the annual meeting will be held at Columbus, Ohio, in 1976. Invitations have been received from St. Petersburg, Florida, and from Tampa, Florida, for future meetings.

Dr. William Clench's report on History and Archives was summarized by President Moore. The Archives, located at the Delaware Museum of Natural History, has some new additions of slides from members. More photos, slides, clippings, etc., are requested.

The auditing report showed books to be balanced and the report of the Treasurer was properly signed. Approved.

A report from Council to authorize ads in several malacological journals to inform the public about AMU and membership was approved. The offer by Dr. Tucker Abbott to mail paperback copies of *American Malacologists* and Supplement to new members in 1975 and 1976 was approved and accepted with appreciation. Dr. Abbott also offered a free ad in *Nautilus*. Approved.

Dr. George Davis reported to Council on possible student awards or student membership category. Council voted to not make such awards in 1976. Council voted to refrain from separate membership for students. Approved.

Dr. Dave Stansbery made a report on the Big Darby litigation which AMU entered in 1974. The matter is still in litigation, and while this is going on the fauna is safe in Big Darby.

Jeanne Whiteside reported to Council that she had few responses to her request for expert witnesses to aid in answering requests for assistance in Conservation problems. She suggested the need for regional chairmen and was asked to secure these by volunteer effort.

Dr. Moore presented Council action in approving the following Resolution:

Whereas, The Deltona Corp. of Florida has applied to the U.S. Army Corps of Engineers, to do extensive dredge and fill at Marco Island, Florida; and

Whereas, The U.S. Army Corps of Engineers, Jacksonville District, is accepting comments to be reviewed and incorporated in the final Environmental Impact Statement; and

Whereas, Dr. A. Myra Keen, Professor Emeritus of Stanford University states:

"The loss of over 50 linear miles of natural shoreline that would be turned into sterile canals and seawalls; the destruction of 2,052 acres of mangroves and the total disturbance of over 4,000 acres in the dredge and fill operations are a matter of grave concern not merely to the people of the immediate area but also to citizens at large. This region borders on the Everglades, which we have been at great pains to set aside as a national park. The lagoons to be destroyed are a part of an ecological system that is of far more than local significance. During my years as a professor at Stanford University I taught a course on Biological Oceanography, and in my studies of the subject came to realize that this part of Florida is one of the richest nursery grounds anywhere on earth. The shrimp, for example, that are harvested a hundred miles to the southwest of there spent their juvenile stages in the warm, nutrient-rich waters of the mangrove swamps in the Everglades area and northward, right in the heart of which this dredge-and-fill operation would be taking place. Thus, the destruction of the habitat would have repercussions not only locally but also for commercial fishermen whose livelihood is gathered tens of miles away."; and

Whereas, The U.S. Army Corps of Engineers, Jacksonville District, will hold a public hearing on this matter, now therefore be it

Resolved, That the *American Malacological Union, Inc.*, wishes to be on record as opposing the issuance of these permits because it would be detrimental to the environment.

President Moore gave a background discussion on Marco Island area. Charles M. Courtney gave a report from Deltona and his work at the Marco Applied Marine Ecology Station. Members asked questions on acreage owned by Deltona. After further discussion, Dr. J.P.E. Morrison made the motion that the resolution be approved. Approved, report of such action to be immediately sent to appropriate parties.

Dues recommended by Council and approved by members are as follows (Effective January 1, 1976)

Regular member (Western Hemisphere)	\$7.00
Each additional family member (one mailing)	\$1.00
Corresponding member (outside Western Hemisphere)	\$7.00
Each additional family member (one mailing)	\$1.00
PLUS Postage by Seamount	\$1.50
Affiliate member (shell club, corp., library, museum, etc.)	\$10.00
New member fee or reinstatement fee of \$1.50 to remain the same.	
All above categories receive all mailings and the Bulletin, plus listing in the Bulletin.	
Subscription for Bulletin only (Institutional, may be had on continual billing)	\$10.00

There was some discussion on possible cut rates for charter or "over-65" members and postage fees. No Action.

The Budget Committee, composed of Dr. Harald Rehder, chairman, and Drs. Abbott and Bill Ermerson, proposed the following budget for 1976:

RECEIPTS ANTICIPATED:

Memberships	\$5,000
Sales: (HTSCS)	550
Sales: Back issues of Bulletin	100
From 1975 meeting	300
Page charges--Bulletin	1,000
Miscellaneous income	50
	\$7,000

EXPENDITURES ANTICIPATED:

Printing Bulletin	\$4,200
Printing Newsletter	1,000
Printing Miscellaneous	250
Conservation Committee	100
Postage	500
Office Supplies and Expenses	200
State of California Filing Fee	5
Travel for Secretaries, Treasurer	500
Expenses for President, Vice-President	100
Expenses for Editor	50
Miscellaneous	95
	\$7,000

Dr. Rehder noted that a separate amount of \$600.00 was designated to go back into the Capital fund from sales of *How to Study and Collect Shells*.

It was reported by President Moore that Council had approved mandatory charges for papers published in the Bulletin over 500 words. Dr. Dundee, Editor, would announce charges after checking out printing costs. The 1975

Bulletin will be a joint Bulletin with the Western Society of Malacologists, a large issue. Costs would be worked out by the Editors. WSM will publish and distribute its membership list separately. Only one Bulletin will be mailed to a member, even though member in both organizations.

A call for new business to be brought to the attention of full membership gained no response. The motion to adjourn was approved. The forty-first annual meeting of AMU closed at 4:30 p.m., with the banquet that night to be the final session for AMU.

REPORT OF THE TREASURER FOR THE FISCAL YEAR ENDING DECEMBER 31, 1974.

CHECK BOOK BALANCE, JANUARY 1, 1974

1,881.98

RECEIPTS:

Memberships:		
Regular	2449.75	
Corresponding	92.25	
Sustaining	75.00	
Clubs & Institutions	<u>528.75</u>	3145.75
Sales: HOW TO STUDY & COLLECT SHELLS	92.00	
RARE & ENDANGERED SPECIES	2.65	
Back Issues, BULLETIN	<u>101.87</u>	196.52
Proceeds of Springfield Meeting	366.08	
Page charges to authors	811.00	
Contributions to Legal Fund	103.40	
Miscellaneous receipts	<u>111.68</u>	1392.16
Total receipts from activities		4734.43
Transferred from Savings Account		<u>2000.00</u>
		<u>6734.43</u>
TOTAL CASH ACCOUNTED FOR:		8616.41

DISBURSEMENTS:

Costs, 5,000 copies of HOW TO	
STUDY & COLLECT SHELLS	3041.86
BULLETIN	2664.65
NEWSLETTERS	826.28
Conservation Committee	23.67
Membership Committee	25.00
Other printing	88.05
Other postage	217.53
Expenses for 2 officers to Springfield	592.92
Filing Fee, State of California	5.00
Office supplies	52.04
Miscellaneous expenses	<u>136.05</u>
Total disbursements	7673.05
	7673.05

CHECK BOOK BALANCE, DECEMBER 31, 1974

943.36

TOTAL CASH ACCOUNTED FOR:

8,616.41

Savings Acct #2-6621, 1st Federal Savings	*2299.62	
Withdrawn from Savings	2000.00	
Interest added - Balance 12/31/74	*108.21	*407.83
Savings Cert. #60-3332 02 1st Federal	*3162.86	
Interest added - Balance 12/31/74	*220.86	*3383.72

RECAPITULATION OF ASSETS, DECEMBER 31, 1974:

Cash in checking account, Broadway National Bank	\$ 943.36
Treasurer's Petty Cash, Myra Taylor	25.00
Secretary's Petty Cash, Marian Hubbard - closed out	-0-
Secretary's Petty Cash, Constance Boone	75.00
Savings Account #2-6621, 1st Federal Savings & Loan	407.83
Certificate of Deposit #60-332 02, 1st Federal Savings & Loan	<u>3383.72</u>

TOTAL ASSETS: \$4834.91

ALLOCATED TO LIFE MEMBERSHIP FUND: 1595.88

A.M.U. NET WORTH - DECEMBER 31, 1974 3239.03

CHANGES IN CAPITAL ACCOUNT:

A.M.U. CAPITAL ACCOUNT, JANUARY 1, 1974	5701.98
A.M.U. CAPITAL ACCOUNT, DECEMBER 31, 1974	<u>3239.03</u>

NET DECREASE IN ASSETS IN 1974 \$2462.95

Respectfully submitted,
Myra L. Taylor, Treasurer

AUDITED:

Thomas E. Pulley	15 June, 1975
Harold D. Murray	7 March, 1975
Bessie G. Goethel	7 March, 1975

TREASURER'S NOTES: DECREASE IN NET ASSETS DUE TO SEVERAL FACTORS:

1. Cost of new edition, 5,000 copies of HOW TO STUDY & COLLECT SHELLS
2. Increased costs of paper, printing and postage, etc.
- *3. Savings accounts were moved in order to benefit by increased interest rates, from 5% to 5¼% on Passbook, and from 5¾% to 6¾% on CD. Extra interest on old Passbook #8289670 was 31.59 and on CD was 140.01, after books were closed for 1973. Hence, the difference in old figures for 1973 and new ones for 1974.

REPORT OF THE RECORDING SECRETARY

Memberships for 1974 reviewed in January, 1975, were as follows:

Honorary Life Members	6
Honorary Life President	1
Regular Memberships	
(all Western Hemisphere)	551
Additional Family Members	105
Corresponding memberships	15
Affiliated Memberships	
(Institutions)	
Domestic	29
Foreign	11
Clubs, Regional organizations	47
Life Members	20
Total 785	

Several 1974 memberships were accepted after January, due to some mail delays, etc., so that the 1974 total did reach the total of 1973.

The count above compares with recent years as follows: 1973, 790; 1972, 760; 1971, 717. Only the totals can be compared because a realignment has been made on regular memberships in accordance with the By-Laws which state

that all members residing in the Western Hemisphere are regular members.

A check with the Treasurer's records confirms the following statistics: Unpaid 1974 memberships include 104 regular members, 2 affiliate members, and 3 corresponding members; 9 regular members resigned; 2 affiliates resigned; 3 deaths.

By the end of 1975 new cards will be completed. A request is made from members to update titles and areas of study and interest for use in the Bulletin Membership list.

As of June 1, 1975, we have 42 new members, 3 new affiliates, one reinstatement, and three new life members. There have been four deaths and one resignation.

Correspondence consists of letters of welcome to new members, mailing of Newsletters to new members, mailing of copies of *Rare* and *Endangered Species Symposium* and old Bulletins. There is a continual flow of correspondence on the collection of the initial membership fee of \$1.50 which is frequently overlooked by new members.

Respectfully submitted,
Constance E. Boone
Recording Secretary

REPORT OF CORRESPONDING SECRETARY 1975

Publication of "How to Study and Collect Shells" was a boon and found ready acceptance once the booklets arrived just before Christmas 1974. Several (16) of the shell clubs took advantage of the offer of 25 per cent off the cost in quantities of 10 or more and 40 per cent off on quantities of 50 or more. Form letters had gone out in November urging them to grab the opportunity. A total of 358 copies were distributed this way. Letters also went out to persons who had sent checks for the previous booklet. And several of these placed orders for copies. There are still persons sending in \$2 checks, as indicated in some of the older shell guides. Booklets go out to these folks and most of them have sent in balances. A few \$1 checks have come in. These are returned with the request to send a check of the larger amount. Included in the letter is a list of books available -- which may help indicate the bargain they're receiving in the AMU guide. Assisting in this booklet distribution project were R. Tucker Abbott and Karl Jacobson. Karl rode herd on the booklet's printers and managed to find a temporary home for the

booklets with Tucker, both of them sending me boxes when I requested them.

Form letters have continued to lessen the chore of writing to persons inquiring about the organization, the hobby, the list of clubs, and occasionally "what do you do in the AMU?" A few of those wishing more detailed information on whom to contact in a particular field take a bit more time and more correspondence. The corresponding secretary was glad to see that more persons in distant lands are learning English. There have been fewer letters in Spanish, Italian and German, which, fortunately, he is still able to read.

The AMU's resolution on the Panama Canal was published in the August 1974 issue of the SFI Bulletin, published by the Sport Fishing Institute. Shortly after I received my copy, I got a call from a radio newsmen in Michigan. He asked questions on the resolution with the interview later broadcast over the University of Michigan network.

Respectfully submitted, Paul R. Jennewein
Corresponding Secretary.

THE AMERICAN MALACOLOGICAL UNION, INC. ACTIVE MEMBERS 1975

Membership List Revised September 1, 1975

- Abbott, Dr. R. Tucker, Delaware Museum of Natural History, Box 3937, Greenville, DE. 19807.
- Abbott, Mrs. Sue D., Suite D-1-A, R.D. 3, Box 250, Hockessin, DE. 19707.
- Abreu, Mrs. Vivian B., 2709 Dewey St., Tampa FL. 33607 (Sea life relationship to human race).
- Aguayo, Dr. Carlos G., Dept. of Biology, Univ. of Puerto Rico, Mayaguez, Puerto Rico 00708.
- Alarcon, Sr. Benito Fuenzalida, Correo, Isla de Pascua, Chile (Easter Island species).
- Albert, Mr. and Mrs. Ernest, 905 S. Bayshore, Safety Harbor, FL. 33572.
- Alexander, Robert C., 423 Warwick Rd., Wynnewood, PA. 19096.
- Allen, James E., 1108 Southampton Dr., Alexandria, LA. 71301 (Tertiary micro-mollusca).
- Allen, Dr. J. Frances, 7507 23rd Ave., Hyattsville, MD. 20783.
- Allen, Mr. and Mrs. Lawrence K., Box 822, Port Isabel, TX. 78578 (*Murex*, *Pecten*, world marines; dealer).
- Allen, Miss Letha S., 187 Argyle St., Yarmouth, Nova Scotia, Canada B5A 3X2 (General).
- Anders, Kirk W., Shells of the Seas, Inc., P.O. Box 1418, Ft. Lauderdale, FL. 33302 (*Volutidae*, all rare shells).
- Anderson, Carleton Jay Jr., 56 Kettle Creek Rd., Weston, CT. 06880.
- Anderson, Gregory L., Pacific Marine Station, Dillon Beach, CA. 94929.
- Anderson, Richard V., Dept. of Biological Scs., Northern Ill. Univ., DeKalb, IL. 60115 (Freshwater Pelecypods).
- Andrews, Jean, 200 Ave. D., #363, Denton, TX. 76201.
- Angstadt, Mrs. Earle K., 247 Penn St., Reading, P.A. 19602.
- Arnold, Charles E., 3206 Floyd Ave., Richmond, VA. 23221 (Collecting, photographing).
- Aslakson, Capt. Carl I., 5707 Wilson Lane, Bethesda, MD. 20034.
- Athearn, Mr. and Mrs. Herbert D., Museum of Fluvatile Mollusks, Rt. 5, Box 499, Cleveland, TN. 37311 (Freshwater mollusks).
- Athearn, Mrs. Roy C., 5105 N. Main St., Fall River, MA. 02720 (Land shells).
- Avellanet, Mrs. Helene, 105 Clipper Way, Fair Winds Villas, Nokomis, FL. 33555.
- Avery, Mrs. R. Gail, Box 2557, Harbor, OR. 97415 (West American mollusks; exchange).
- Babrkazai, Mr. Noorullah, % General SIVOOSHJ SAMSAM; Vanak, Tehran, Iran
- Baeris, David A., 1233 Sweet Briar Rd., Madison WI. 53705 (Paleoecological interpretation through mollusks)
- Bagdon, Mr. and Mrs. Anthon, 440 Home Dr., Trafford, PA. 15085.
- Baily, Dr. Joshua L. Jr., 4435 Ampudia St., San Diego, CA. 92103.
- Baker, Mrs. Horace B., 11 Chelton Rd., Havertown, PA. 19083.
- Baker, John A., 147 Hedgegrove Ave. Satellite Beach, FL. 32937 (General).
- Baker, Nelson W., 69-990 Papaya Lane, Cathedral City, CA. 92234 (General).
- Balsam, Arthur, 1911 Fawn Dr., Philadelphia, PA. 19118.
- Banek, Thomas J., 466 Thatcher Rd., Springfield, PA. 19064 (Marine gastropods, taxonomy and ecology).
- Barker, C. Austin, 2 Hickory Dr., Rye, NY. 10580
- Barlow, Mrs. G. Barton, 5 Downey Dr., Tenafly, NJ. 07670
- Barnett, Mr. and Mrs. George H., Koran Ave., M.D. #23, Newburgh, NY. 12550.
- Barton, Mrs. James, 20 Newfield Dr., Rochester, NY. 14616 (*Cypraea*; worldwide general, esp. Hawaiian).
- Bateman, William J., 15 Pilgrim Circle, Methuen, MA. 01844 (*Cypraea*, *Voluta*).
- Bates, Dr. John M., 1900 Dexter Ave., Ann Arbor, MI. 48103.
- Battles, Harold J., 502 Pinon Dr., Morro Bay, CA. 93442 (Worldwide marine).
- Bauchman, Frank A., 1601 Big Bethel Rd., Hampton, VA. 23666 (Collecting).
- Bauer, Mr. and Mrs. Hugo C., 2126 45th St., Galveston, TX. 77550 (all Mollusca).
- Baum, Newman N., 83 Weaving Lane, Wantagh, L.I., NY. 11793.
- Baxa, Mrs. Dorothy, Box 177, Genesee Depot, WI. 53127.
- Bayne, Dr. C.J., Dept. of Zoology, Oregon State Univ., Corvallis, OR. 97331 (Gastropod physiology).
- Bazata, Kenneth E., Industrial Biotest Labs, Inc., Bldg. 1374; Air Park West, Lincoln, NE. 68524 (Terrestrial pulmonates; *Dentalium*).
- Bearse, David T., Grad. School of Oceanography, Univ. of R.I., Kingston, RI 02881 (Shellfisheries).
- Beetle, Ms. Dorothy E., 375 W. Galbraith Rd. #42, Cincinnati, OH. 45215.
- Bennett, Sally, 514 W. Rose Lane, Phoenix, AZ. 85013 (Panamic Province shells).
- Bennett, Dr. Terry M., Medical Advisor, U.S. Embassy, APO New York, NY. 09697 (Exchange).
- Bequaert, Dr. Joseph C., Dept. of Entomology, Univ. of Arizona, Tucson, AZ. 85717.
- Bereza, Daniel J., 825 N. 24th St., Philadelphia, PA. 19130 (Unionidae/Pleuroceridae).
- Berman, Lynn, 8 Peter Cooper Rd., New York, NY. 10010 (Marine).
- Berry, Dr. and Mrs. Elmer G., 8506 Beech Tree Court, Bethesda, MD. 20034.
- Berry, Dr. S. Stillman, 1145 W. Highland Ave., Redlands, CA. 92373.
- Bickel, David, Dept. Earth Sciences, Minot State College, Minot, ND. 58701 (Systematics and ecology of freshwater mollusks, esp. Pleurocerids).

- Bijur, Jerome M., 135 Seventh Ave. N., Naples, FL 33940 (Buy, exchange Florida and Caribbean marine).
- Bing, Ruth Rosser, P.O. Box 2612, Muhlenburg Station, Plainfield, NJ. 07060 (Art-Photography, oil painting).
- Bippus, Mr. and Mrs. Alvin C., 2743 Sagamore Rd., Toledo, OH. 43606 (Marine gastropods).
- Blankenship, Shaw, Rt. #2, Crab Orchard, KY. 40419 (Freshwater mussels).
- Blaser, James, 1846 Laurel Lane, Amherst, OH. 44001 (Florida mollusks; Ohio freshwater mollusks).
- Bleakney, Dr. J. Sherman, Dept. of Biology, Acadia Univ., Wolfville, Nova Scotia, Canada BOP 1X0 Nudibranchs and sacoglossans; ecology, zoogeography, systematics).
- Bledsoe, William D., 352 Bon Hill Rd., Los Angeles, CA. 90047.
- Boone, Mr. and Mrs. Hollis Q., 3706 Rice Blvd., Houston, TX. 77005.
- Borror, Kathy Gail, 612 Northridge Rd., Columbus, OH. 43214.
- Boss, Dr. Kenneth J., Museum of Comparative Zoology, Harvard Univ., Cambridge, MA. 02138.
- Bottimer, L.J., Rt. 1, Box 50, Tow, TX. 78672 (Recent and fossil mollusks).
- Bowen, Philip R., 1004 Collins St., Hartsville, SC. 29550.
- Boyd, Dr. and Mrs. Eugene S., 6806 Gillis Rd., Victor, NY. 14564 (Phylum Mollusca - all aspects).
- Bradley, J. Chester, 604 Highland Rd., Ithaca, NY. 14850.
- Brady, Mr. and Mrs. E. Leo, P.O. Box 2515, Newburg, NY. 12550 (Land snails).
- Brandyberry, John J., 6323 Middlebranch Ave., NE, North Canton, OH. 44721 (Marine mollusca).
- Branson, Dr. Branley A., P.O. Box 50, Eastern Kentucky Univ., Richmond KY. 40475.
- Bratcher, Mrs. Twila, 8121 Mulholland Terrace, Hollywood, CA. 90046.
- Brean, Clark, 705 E. Sherman, Lebanon, OR. 97355 (Student, Cypraea).
- Bretsky, Mrs. Sara S., 91 Dept. of Earth and Space Sciences State Univ. of NY, Stonybrook, NY. 11794. (Ecology and evolution of Bivalvia, Tertiary and Recent).
- Bricker, Mrs. Minnie, Miss Donna Bricker, Walter Kurman, R.D. 3, Hanover, PA. 17331 (Conchs and Whelks).
- Brill, Mr. and Mrs. James A., 804 Johnson St., Terrell, TX. 75160.
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- Brooks, Dr. and Mrs. James C. Jr., P.O. Box 490127, College Park, GA 30349 (Cypraea, Murex).
- Brown, Dr. and Mrs. Harvey E. Jr., 9455 S.W. 81st Ave., Miami, FL. 33156.
- Broyles, Dr. and Mrs. Ralph E., 5701 Fairfield Ave., Ft. Wayne, IN. 46807.
- Brunson, Dr. Royal Bruce, Univ. of Montana, Missoula, MT. 59801.
- Bryan, Edwin H. Jr., Bishop Museum, P.O. Box 6037, Honolulu, HI. 96818 (Pacific biogeography and bibliography).
- Buckley, George D., 164 Renfrew St., Arlington, MA. 02174.
- Buehler, William, 113 16th Ave. East, Ashland, WI. 54806 (Freshwater mollusks).
- Buerk, Dr. Minerva S., Maybrook Chalet, 331 Penn Rd., Wynnewood, PA. 19096 (Anatomy, histology).
- Bullis, Harvey R. Jr., 121 Island Dr., Key Biscayne FL. 33149.
- Burch, Mrs. John Q., 1300 Mayfield Rd., Apt. 61-L, Seal Beach, CA. 90740.
- Burch, Dr. and Mrs. Thomas A., P.O. Box 309, Kailua, HI. 96734 (Dredging).
- Burger, Sybil B., 3700 Gen. Patch N.E., Albuquerque, NM 87111 (Gulf of Mexico; land snails).
- Burgers, Dr. and Mrs. J.M., Institute Fluid Dynamics, U. of Maryland, College Park, MD. 20742.
- Burghardt, Mr. and Mrs. Glenn, 14453 Nassau Rd., San Leandro, CA. 94577.
- Burke, Mr. and Mrs. Thomas D. Jr., 1820 S. Austin Blvd. Cicero, IL. 60650 (Marine mollusks of Eastern USA).
- Burky, Dr. Albert J., Dept. of Biology, Univ. of Dayton, Dayton, OH. 45409.
- Cahill, Michael, 1639 Madison St., Apt. #4, Hollywood, FL. 33020 (Florida marine).
- Cameron, Hugh C., 3704 Edwards Rd., Cincinnati, OH. 45208 (Collecting).
- Campbell, Mrs. Minnie Lee, 3895 DuPont Circle, Jacksonville, FL. 32205 (General).
- Canon, Sr. Jose R., Instituto de Fomento Pesquero, Casilla 1287, Santiago, Chile (Benthic ecology; South American Mollusca).
- Capo, Thomas R., 28 Windward Lane, Easthampton, NY. 11937 (Benthic ecology).
- Cardeza, R. Adm. and Mrs. Carlos M., P.O. Box 6746, Houston, TX. 77005; summer add.-1718 Jewel Box Dr., Sanibel, FL. 33957 (Florida and Texas shells).
- Cardin, MSGT. Charles, Box 3539, APO San Francisco, CA. 96328.
- Carlton, James T., Dept. of Geology, Univ. of California, Davis, CA. 95616 (Estuarine and brackish water mollusks).
- Carney, Dr. W. Patrick, Dept. of Experimental Parasitology NMRI, NNMC, Bethesda, MD. 20014.
- Carr, Mrs. Jack C., 912 Broadway, Normal, IL. 61761 (Exchange worldwide marines).
- Castagna, Michael, Va. Institute of Marine Science, Wachapreague, VA. 23480 (Pelecypod larval behavior).
- Cate, Mr. and Mrs. Crawford N., P.O. Drawer 710, Rancho Santa Fe, CA. 92067. (Mitra, Cypraea; no exchanges).
- Cetnar, Dr. and Mrs. Eugene J., 4322 Bishop Rd., Detroit, MI. 48224.
- Chace, Emery P., 24205 Eshelman Ave., Lomita, CA 90717.
- Chandler, Carl B. and Doris M., P.O. Box 621, Chatham, MA. 02633 (Cones, Cypraea).
- Chanley, Mr. and Mrs. Paul E., P.O. Box 645, New Suffolk NY. 11956.
- Chauvin, Daniel, 3950 Hollister #79, Houston, TX. 77055.
- Cheng, Dr. Thomas C., Institute for Pathobiology, Lehigh Univ., Bethlehem, PA. 18015.

- Chichester, Lyle F., 31 Chamberlain St., New Britain, CT. 06052 (Ecology of terrestrial gastropods, biology of land slugs).
- Christie, Dr. John D., The Rockefeller Foundation 111 West 50th St., N.Y., NY. 10020.
- Christensen, Carl C., Dept. of General Biology, Univ. of Arizona, Tucson, AZ. 85721.
- Chrosicchowksi, Przemyslaw K., Aptdo. 125, Maracay 3KO, Venezuela (Planorbidae).
- Clark, John W. Jr., Texas Historical Commission, P.O. Box 12276, Capitol Station, Austin, TX. 78711 (Economic exploitation of mollusks by prehistoric Indians).
- Clarke, Dr. Arthur H., Head Invertebrate Division National Museums of Canada, Ottawa, Ont., Canada K1A 0M8.
- Clarke, Michael D., 1179 Brown Rd., Hanover, MI. 49241.
- Clench, Dr. William J., 26 Rowena St., Dorchester, MA. 02124.
- Clover, Phillip W., P.O. Box 83, Glen Ellen, CA. 95442.
- Coan, Dr. Eugene V., 891 San Jude Ave., Palo Alto, CA. 94306.
- Cohen, Anne C., 6803 Florida St., Chevy Chase, MD. 20015 (Loliginidae; *Litiopa melanostoma*).
- Coleman, Dr. Richard W., Dept. of Biology, Upper Iowa College, Fayette, IA. 52142. (Environmental interrelationships, plants-invertebrates).
- Compitello, Mrs. Juliette, 5630 Alta Vista Rd., Bethesda, MD. 20034.
- Cooper, Robert W., 5012 Pfeiffer Rd., Peoria, IL. 61607 (Florida marine; *Murex*, *Pecten*, *Spondylus*, *SCUBA*).
- Corgan, Dr. James X., Dept. of Geography and Geology, Austin Peay State Univ., Clarksville, TN. 37040 (Microscopic gastropods).
- Courtney, Charles M., c/o Marco Applied Marine Ecology Station, North Barfield Dr., Marco Is., FL. 33937 (Aquatic ecologist/malacologist).
- Craig, Michael M., Div. of Biol. Sciences, the Univ. of Mich., Ann Arbor, MI. 48104.
- Craine, Mrs. Ruth A., Penick Memorial Home "F", East Rhode Island Ext., Southern Pines, NC. 28387.
- Cramer, Frances L., 766 Obispo Ave., Long Beach, CA. 90804 (Ecology; conservation).
- Cull, Mrs. Robert R., 7927 Chippewa Rd., Brecksville, OH. 44141.
- Cummings, Raymond W., 37 Lynacres Blvd., Fayetteville, NY. 13066 (West Indies shells, esp. Windward and Grenadine Is.).
- Curington, Roberta M., 6746 Ransome Dr., Baltimore, MD 21207 (Marine gastropods).
- Cutler, Mr. and Mrs. Henry H., 105 Abbott Rd., Wellesley Hills, MA. 02181.
- Cvancara, Dr. Alan Milton, Dept. Geology, Univ. of N. Dakota, Grand Forks, ND. 58201 (Pleistocene and Holocene continental mollusks, early Tertiary continental and marine).
- Danforth, Louise L., 2920 Yorktown St., Sarasota, FL 33581.
- Daniels, Mrs. Kathleen K., 121 Stephens Lane, Verona, PA. 15147 (Marine; educational materials).
- Daniels, Ronnie H., 101 Brock Ave., Blytheville, AR. 72315 (Marine: *Volutes*, *Murex*, *Cowries*).
- Davenport, Mrs. Lillian B. 802 Cape Ave., Cape May Point NJ. 08212 (Anything pertaining to the sea).
- Davis, Dr. Derek S., Nova Scotia Museum, 1747 Summer St., Halifax, Nova Scotia, Canada B3M 3A6 (Gastropod biology and taxonomy).
- Davis, Dr. George M. and Davis, Dr. Elsie Hoagland, Dept. of Mollusks, Academy of Natural Science, 19th and the Parkway, Philadelphia, PA. 191C3, and (Mrs.) Ass't. Prof. of Biology, Lehigh Univ., Bethlehem, PA 18015.
- Davis, Dr. John D., 26 Norfolk Ave., Northampton, MA. 01060 (Ecology of marine bivalves).
- Deatrick, Paul A., 218 S.W. 32 Ave., Miami, FL. 33135 (*Strombus*, *Busycora*).
- de Graaff, Gerritt, 10915 S.W. 55 St., Miami, FL. 33165.
- DeLuca, Mrs. John A., and Miss Gladys DeLuca, 61 Deborah Rd., Hanover, MA. 02339.
- Dennis, Ms. Sally, TVA, Forestry, Fisheries, and Wildlife Develop., Norris, TN. 37828 (Freshwater mussels).
- DeOliveira, Dr. Maury Pinto, Dept. Biologia-Malacologia, Universidade Federal De Juiz De Fora, Cidade Universitaria, 36100 Juiz de Fora, Minas Gerais, Brazil
- Demond, Miss Joan, 4140 Grandview Blvd. #1, Los Angeles, CA. 90066.
- Dexter, Miss Norma, 135 E. Main St. #3, Clinton, CT. 06413 (*Cypraea*).
- Dexter, Dr. and Mrs. Ralph W., Dept. Biological Science, Kent State Univ., Kent, OH. 44242.
- Dietrich, Mr. and Mrs. Louis E., 308 Veri Dr., Pittsburgh, PA. 15220.
- Dixon, Mrs. Ruth S., 711 Parker St., Durham, NC. 27701 (Marine).
- Dobos, John D., 1300 Porter, Apt. 45, Dearborn, MI. 48124.
- Duarte, Sr. Eliseo, Casilia Correo 1401, Central, Montevideo, Uruguay.
- DuBar, Dr. and Mrs. Jules R., Lakeview Hgts., Morehead, KY. 40351 (Cenozoic and recent mollusks - ecology and paleoecology).
- Dundee, Dr. Dolores S., Dept. of Biology, Univ. of New Orleans-Lakefront, New Orleans, LA. 70122 (Land mollusks, freshwater mussels).
- Draper, Bertram, C., 8511 Blierot, Los Angeles, CA. 90045
- Druger, Dr. George, Box 172, Tripler AMC, APO San Francisco, CA. 96438 (Scuba).
- Dvorak, Stanley J., 3856 W. 26th St., Chicago, IL. 60623 (Muricidae).
- Dyer, Mr. and Mrs. John S. Jr., Box 238, Brookside, NJ. 07926 (Gastropods).
- Eddison, Dr. Grace G., Region D., Respiratory Disease Hospital, Paris, KY. 40361.
- Edmiston, Mrs. J.R., 5038 Hazeltine Ave., Apt. 301, Sherman Oaks, CA. 91423.
- Edwards, Lt. Col. Corinne E., USAF (Ret.), P.O. Box 691, Coconut Grove, FL. 33133 (Chitons; self-collected).
- Edwards, D. Craig, Dept. of Zoology, Morrill Science Center, Univ. of Massachusetts, Amherst, MA. 01002

- (Population ecology and behavior of marine benthic molluscs).
- Emerson, Dr. William K., American Museum of Natural History, Central Park West at 79th St., New York, NY. 10024.
- English, Rita C. and English, James F., 10300 Terrace Court, Parma, OH. 44130 (Fossils; Florida and Caribbean; ecology of mangrove areas).
- Erickson, Carl W., 4 Windsor Ave., Auburn, MA. 01501.
- Eubanks, Dr. Elizabeth R., 2162 E. Minton Dr., Tempe, AZ. 85282. (Florida marine).
- Evans, Miss Susan E., 244 Congress Ave., Lansdowne, PA 19050 (*Conus*, *Cypraea*, *Murex*).
- Eversole, Dr. Arnold G., Dept. of Entomology and Economic Zoology, Clemson Univ., Clemson, SC. 29631 (Interpopulation variation and bioenergetics of molluscan populations).
- Fackert, Miss Dorothy M., 2 Wilson Rd., Apt. 16B, Sussex, NJ 07461.
- Farber, Mrs. Jeanie, 4169 Carmain Dr. N.E., Atlanta, GA 30342 (all shells).
- Farrell, Dr. Lyle H., Box 57, Andover, NH. 03216.
- Fechtnr, Frederick R., 2611 W. Fitch Ave., Chicago, IL. 60645.
- Feinberg, Harold S., Dept. of Fossil and Living Invertebrates, American Museum of Nat. Hist., Central Park West at 79th St., N.Y., NY 10024 (Land and freshwater mollusks).
- Fenzan, William J., 385 Dohner Dr., Wadsworth, OH. 44281 (Worldwide marine).
- Ferguson, Dr. and Mrs. John H., 226 Glandon Dr., Chapel Hill, NC. 27514.
- Ferreira, Dr. Antonio J., 2060 Clarinar Way, San Jose, CA 95128 (Ecology, behavior, physiology, systematics of American Mollusca).
- Fieberg, Mrs. Kleinie, 1430 Lake Ave., Wilmette, IL. 60091.
- Fingold, Mr. and Mrs. A.S., University Square #1, 4625 Fifth Ave., Apt. 105, Pittsburgh, PA. 15213.
- Finlay, C. John, 116 Tanglewood Lane, Newark, DE. 19711 (Marine mollusks Western Atlantic and Caribbean).
- Flansburg, Dr. Ronald R., 2910 Pomona Court, Brookfield WI. 53005.
- Foehrenbach, Jack, 91 Elm St., Islip Manor, NY. 11751 (Marine ecology).
- Foot, Miss Mary K., Box 2075, South Padre Island, TX. 78578.
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- Foster, Mr. and Mrs. Edward W., 30 Bamboo Dr., Naples FL. 33940.
- Foster, Mrs. Fred H., 401 N. Justus St., Oxford, IN. 47971.
- Fowler, Dr. and Mrs. Lake, 4508 Woodrow, Galveston, TX 77550.
- Franke, Norman W., 1651 Nash Ave., Pittsburgh, PA. 15235 (Self-collected marine).
- Fox, Mr. and Mrs. Arnold, 112 Rennard Place, Philadelphia PA 19116 (*Pecten*, *Spondylus*, *Murex*).
- Franz, Dr. David R., Biology Dept., Brooklyn College, Brooklyn, NY 11210 (Ecology and physiology, marine mollusks, esp. Nudibranchs).
- Franzen, Dr. Dorothea, Illinois Wesleyan Univ., Bloomington, IL. 61701.
- Fraser, Stanley, R. 5, Smiths Falls, Ont., Canada K7A 4S6.
- Fuller, Samuel L.H. and Mrs. Mary L.B. Fuller, Academy of Natural Sciences, 19th and the Parkway, Philadelphia PA 19103 (World Naiads, Unionacea and Mutelacea).
- Fullington, Richard W., 1111 Ave. A., Denton, TX 76201 (Land and freshwater gastropods of N.A.; Curator, Invertebrate Zoology, Dallas Museum of Nat. Hist.).
- Gad, Kathleen J., 8911 W. Burleigh, Milwaukee, WI 53222.
- Gale, Dr. William F., Ichthyological Assoc. Inc., R.D. #1, Berwick, PA. 18603 (Sphaeriids).
- Galindo, Lic. Ernesto Santos, Lopez #1, 6. Piso, Mexico, D.D.I., Mexico.
- Gallagher, Mrs. Susan, 12250 6th St. East, Treasure Island FL 33706.
- Garoian, Dr. George, Dept. of Zoology, Southern Illinois Univ., Carbondale, IL. 62901.
- Gilbert, Mrs. Laura, 808 Westwood Dr., Abilene, TX 79603.
- Gilbert, Prof. and Mrs. William H., Dept. of Biol., Colby College, Waterville, ME. 04901 (Marine and freshwater bivalves).
- Gilmour, Dr. Thomas H.J., Dept. Biology, Univ. of Saskatchewan, Saskatoon, Sask., Canada S7N 0W0 (Anisomyarian bivalves).
- Girardi, Dr. Elizabeth-Louise, 707 Kent Rd, Kenilworth IL 60043.
- Glazebrook, Sandra R., P.O. Box 651, Marathon, FL 33050.
- Glick, Dr. Robert N. 13500 E. 12 Mile Rd., Warren, MI 48093 (Cowries, cones, olives).
- Goethel, Lt. Col. (Ret.) and Mrs. Louis N., 9402 Nona Kay Dr., San Antonio, TX 78217 (*Cypraea* - buy and trade).
- Goodfriend, Glenn A., Comm. on Evol. Biology, U. of Chicago, IL. 60637 (Molluscan ecology).
- Graf, Robert A., 3217 Maxim Dr., Fort Wayne, IN 46805.
- Greenberg, Bayle, c/o Tidepool Gallery, 3907 W. 50th St., Edina, MN. 55424.
- Greenberg, Mrs. Janis, 22762 Pacific Coast Hwy., Malibu, CA. 90265 (Tidepool Gallery).
- Greenbert, Mrs. Ruth, 22762 Pacific Coast Hwy., Malibu, CA. 90265 (Tidepool Gallery).
- Gregg, Dr. Wendell O., 2546 Hill St., Huntington Park CA. 90255.
- Grimm, F. Wayne, 356 Mayfield, Apt. 3, Vanier, Ont., Canada (Holarctic terrestrial mollusks).
- Groeneveld, Miss Mae, 1183 Terrace St., Muskegon, MI. 49442 (*Cypraea*, *Conus*).
- Guckert, Richard H., P.O. Box 185, Thomasville, GA. 31792 (Systematics of freshwater mussels; ecology; physiology of Nassariidae).
- Gudnason, Mrs. Harold, 105 Danefield Place, Moraga, CA 94556.
- Gugler, Dr. Carl W., 305 Bessey Hall, U. of Neb., Lincoln, NE. 68508 (Terrestrial pulmonates).
- Gunter, Dr. Gordon, Gulf Coast Research Lab., Ocean Springs, MS. 39564 (Ostreidae).

- Gustave, Al, 3829 North Third St., Phoenix, AZ., 85012 (*Murex*, *Astraea*, *Latiaxis*).
- Haas, Dr. John W., 1653 Medical Arts Bldg., Minneapolis MN, 55402 (*Volutes*, *Pectens*, *Spondylus*).
- Hadley, Mrs. Esther, 48 Adella Ave., West Newton, MA. 02165.
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- Hand, Dr. Cadet H., Bodega Marine Lab., P.O.Box 247 Bodega Bay, CA. 94923.
- Hange, Mrs. Maye E., 923 Arbor St., Costa Mesa, CA. 92627.
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- Hargreave, Dr. David, Ass't. Prof. Nat. Scs., College of Gen. Studies, Western Mich. Univ., 1104 Berkshire Dr., Kalamazoo, MI. 49007 (Collecting and photography).
- Harman, Dr. Willard N., Biology Dept., SUNY College at Oneonta, Oneonta, NY. 13820 (Fresh water mollusca).
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- Harris, Mr. & Mrs. E. Milton, 3237 Carlisle Rd., Birmingham, AL. 35313.
- Harris, Major Marion J. and Mrs. Bessie B. Harris, Rt. 6, Box 347 T, Jacksonville, FL. 32223.
- Harrison, Mrs. Francis F., One Beaver St., Cooperstown, NY. 13326.
- Harry, Dr. Harold W., 4612 Evergreen St., Bellaire, TX. 77401.
- Haven, Dr. Dexter S., 336 Lafayette Rd., Yorktown, VA. 23690 (*Mercenaria mercenaria*, *Mya arenaria*, *Crassostrea virginica*).
- Hecht, Mrs. Paul L., 3636 Mineola Dr., Sarasota, FL. 33579.
- Heck, Lt. Col. Ralph L., P.O. Box 16712, Temple Terrace, FL. 33617 (Gastropods, esp. *Conus*, *Cypraea*).
- Hedges, Mrs. Arlene, 404 North East St., Crown Point, IN. 46307.
- Henderson, Jerry G., 1729 N.W. Greenbrier Way, Seattle, WA. 98177.
- Hensley, Steven V., 2488 S. Fletcher Dr., Fernandina Beach, FL. 32034 (Ecology of freshwater Pelecypoda).
- Herman, Dr. Richard D., 919 Hamilton Place, Wyomissing PA. 19601 (Collecting *Murex*, *Cypraea*; biology).
- Hepler, Neil M. and Laura E., 435 S. Federal Hwy., Deerfield Beach, FL. 33441 (Cephalopoda, *Conus*, *Cypraeidae*).
- Herr, Mr. and Mrs. Frank L. Sr., 7901 Dewitt Dr., RFD #3, Baldwinsville, NY. 13027.
- Hesse, Mr. and Mrs. Stanley H., 1241 Cocoon Rd., Boca Raton, FL. 33432.
- Hettick, Mrs. G. Riley, 933 Lynnwood Dr., Bartlesville, OK. 74003.
- Hickey, Ms. Mary T., 183 Neck Path Rd., E. Hampton, NY 11937 (Scallops).
- Hickman, Carole S., Biology Dept., Swarthmore College, Swarthmore, PA. 19081 (Tertiary molluscan paleontology).
- Hickman, Mrs. Harriette L., 11015 First Ave., Stone Harbor, NJ. 08247 (Worldwide *Epitonium*).
- Hicks, Mrs. Edwin S., 1522 Palmwood Dr., Eau Gallie, FL 32935 (Recent and fossil marine shells of Western Atlantic).
- Higbee, Florence and Higbee, Joan, 13 N. Bedford St., Arlington, VA. 22201.
- Hill, Frederick C., Univ. of Louisville, Water Resources Lab., Belknap Campus, Louisville, KY. 40208.
- Hillman, Dr. Robert E., Battelle-Clapp Laboratories, Duxbury, MA. 02332 (Molluscan ecology and physiology).
- Hohman, Betty Jean, 10 Ferris, Apt. 101, Highland Park, MI. 48203 (Cones, *Volutes*, *Murices*).
- Holiman, Mrs. and Mrs. Wayne, Box 246, Edinburg, TX. 78539.
- Holle, Dr. Paul A., 131 Holman St., Shrewsbury, MA. 01545 (Salt marsh snails).
- Hollister, Dean S.C., 201 Hollister Hall, Cornell Univ., Ithaca, NY. 14850.
- Homan, Mrs. Jacqueline A., 2208 48th St., Lubbock, TX. 79412.
- Hopkins, Dr. and Mrs. Sewell H., 709 Garden Acres Blvd. Bryan, TX. 77801.
- Hornstein, Leon, 2211 Arden Rd., Baltimore, MD. 21209.
- Houbick, Dr. Richard S., Supervisor for Benthos, Smithsonian Oceanographic Sorting Center, Washington, DC. 20560 (Zoogeography, systematics, evolution).
- Hoyer, Kerry Bryce, 1210 S. Downing, Seaside, OR. 97138 (Olives, Cones, Cowries, *Murex*).
- Hubbard, Mrs. Marian S., 3957 Marlow Court, Seaford, NY. 11783 (Littorinidae; all juvenile mollusks).
- Hubrick, Leslie, 4026 35th St., Meridian, MS. 39301 (U.S. land and freshwater).
- Hulswit, Mr. & Mrs. Mart, 680 West End Ave., New York NY. 10025 (SCUBA).
- Hunkins, Mrs. Ruth E., 133 Brook to Bay, Englewood, FL. 33533 (Miniature shells; exchange).
- Hunter, Dr. R.D., 1630 W. Buell Rd., Lake Orion, MI. 48035 (Physiological ecology of freshwater pulmonates).
- Hurd, John C., 104 Boulevard, LaGrange, GA. 30240 (Systematics of Unionidae).
- Hyett, Dr. and Mrs. Marvin R., 403 Silverhill Rd., Cherry Hill, NJ. 08034.
- Imlay, Dr. Marc J., Bureau of Sport Fisheries and Wildlife Office of Endangered Species, Washington, DC. 20240.
- Ing, Mrs. May C. and Michael B. Ing, Bella Vista Hospital Box 1750, Mayaguez, Puerto Rico 00708 (Small and minute shells of W.I.).
- Ishikawa, Samuel, 551 Fifth Ave., New York, NY. 10017.
- Isom, Billy G. and Wanda S. Isom, Rt. 2, Box 112, Amy Drive, Killen, AL. 35645.
- Jackson, R.H., 5219 Trentwood Dr., New Bern, NC. 28560.
- Jackson, Ralph W., Rt. #1, Box 229, Cambridge, MD. 21613 (Exchange land shells).
- Jacobson, Morris K., 455 Beach 139 St., Rockaway Beach, NY. 11694.

- Jacobson, Mrs. Ursula, 5618 E. Montecito, Phoenix, AZ. 85018 (Indo-Pacific, esp. cones and cowries; West Coast-Panamic).
- James, Brian, 24 The Links Rd., Apt. 210, Willowdale, Ont., Canada
- Janowsky, Robert and Dorothy, 946 Ralph Ave., Brooklyn, NY. 11236 (*Cypraea*, *Murex*, *Volutes*).
- Jenkinson, Mr. and Mrs. John J., 189 W. Lakeview Ave., Columbus, OH. 43202.
- Jennwein, Mr. and Mrs. Paul R., Box 394, Wrightsville Beach, NC. 28480 (Raising mollusks in aquaria; writing and illustrating articles on shell collecting).
- Jensen, Russell H., Box 3937, Delaware Museum of Natural History, Greenville, DE. 19807 (Mollusks of Bermuda).
- Johns, Veronica Parker, c/o Seashells Unlimited, Inc., 590 Third Ave., New York, NY. 10016.
- Johnson, Mrs. Barbara N., 510 Groveland, Minneapolis, MN. 55403.
- Johnson, Col. Harvey A. (Ret.) 3915 S.W. 109th St., Seattle, WA. 98146.
- Johnson, Mrs. Kenneth L., 3206 Sussex Rd., Raleigh, NC. 27607 (World marine).
- Johnson, Richard I., 124 Chestnut Hill Rd., Chestnut Hill, MA. 02167.
- Johnstone, Mrs. Adelaide B., 226 Wasp, Corpus Christi, TX. 78412.
- Johnstone, Mrs. Kathleen Yerger, 2209 River Forest Rd., Mobile, AL. 36605.
- Jones, Mr. and Mrs. Archie L., 4370 S.W. 14 St., Miami, FL. 33134 (*Liguus*).
- Jones, Meredith L., Division of Worms, USNM, Smithsonian Institution, Washington, DC. 20560.
- Jones, Richard H., 1432 Dorsh Rd., South Euclid, OH. 44121.
- Katsaras, Nick, 479B S. Washington Ave., Bergenfield, NJ. 07621.
- Kay, Dr. E. Alison, General Science Dept., Univ. of Hawaii, 2450 Campus Rd., Honolulu, HI. 96822 (Indo-Pacific marine; systematics and ecology).
- Keegan, Mrs. Barbara, c/o Catholic Relief Serv., Apartado 2617, Managua, Nicaragua, Central America (Caribbean and Pacific mollusks of Central America).
- Keeler, James H., 30 Park Lane, Chagrin Falls, OH. 44022 (Marine, esp. micro Gastropods-Epitonidae and Terebridae).
- Keen, Dr. A. Myra, Dept. of Geology, Stanford Univ., Stanford, CA. 94305.
- Keferl, Eugene P., 4766 Riverside Dr., Columbus, OH. 43220. (Terrestrial gastropods).
- Kemper, Mrs. Hessie, 11854 Josse Dr., St. Louis, MO. 63128.
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- Kraemer, Dr. Louise R., Dept. of Zoology, Univ. of Arkansas, Fayetteville, AR. 72701 (Freshwater lamelli-branths).
- Kraeuter, Dr. John N., Virginia Institute of Marine Science, Wachapreague, VA. 23480 (Ecology, distribution and systematics of Scaphopoda; benthic infaunal of U.S. East Coast).
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- Krieger, Kenneth A., P.O. Box 22721 Emory Univ., Atlanta, GA. 30322 (Ecology and systematics of Hydobidae and Pleuroceridae).
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- Lubinsky, Dr. Irene, Dept. of Zoology, Univ. of Manitoba, Winnipeg, Man., Canada R3T 2N2 (Marine bivalves of the Canadian Arctic).
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- Mastenbroek, Paul W., P.O. Box 67, Woodbridge, Ontario L4L 1A9, Canada (Ecology of mollusks in boreal and arctic parts of Atlantic).
- Mathiak, Mr. and Mrs. Harold A., 209 S. Finch St., Horicon, WI. 53032 (History of Wisconsin mussels; species distribution).
- Mattera, Albert and Mrs. Emily, 4501 Traymore St., Bethesda, MD. 20014 (*Murex*).
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**BULLETIN OF
THE AMERICAN
MALACOLOGICAL
UNION, Inc.**

for 1976

FORTY SECOND ANNUAL MEETING

Columbus, Ohio - 2-6 of August 1976

**The American
Malacological Union**



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Published December 30, 1976

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The original plus two copies of manuscripts (full-length or abstracts; indicate which it is) must be submitted to the editor within one month after the annual meeting. No others will be accepted. Each author should also retain a copy of his paper.

Manuscripts must be typed, double-spaced, and in the format described in the *Style Manual for Biological Journals* published by the American Institute of Biological Sciences, 2000 P Street NW, Washington, D.C. 20036. All measurements must be converted to the metric system. Tables should be placed on separate sheets with a title at the top and numbered consecutively with arabic numbers. Legends accompanying photographs must be on separate sheets. Examine the last issue for proper format.

All full-length papers will be sent to at least two external reviewers selected from the AMU Council, or other specialists.

All manuscripts accepted for publication become the property of the AMU and may be edited for style as described above.

Page charges will be levied for all manuscripts. Reprints may be ordered at the time proofs are sent to authors. Reprints may have portions of adjacent papers on them. Due to the high cost of printing we can no longer offer clean copies.

AMU BULLETIN

The AMU Bulletin is the official annual publication of the American Malacological Union. It is published after each annual meeting. Communications about editorial matters should be sent to Dr. Dee Dundee, Editor, Dept. of Biological Sciences, Univ. of New Orleans, LA. 70122. Subscription orders from institutions, inquires about missing issues and other circulation matters should be addressed to Mrs. Constance E. Boone, 3706 Rice Blvd., Houston, TX. 77005. Subscription rate for non-members of the AMU: \$10; back issues for members and affiliate institutions: write for rates and availability; AMU membership: \$7 plus \$1 per additional family member. corresponding membership: (outside W. hemisphere) \$7 plus \$1.50 postage. Affiliate members (shell clubs, libraries, museums, etc.): \$10. Initiation or reinstatement fee for any member: \$1.50. Printing by the Hauser Press, Inc., New Orleans. Typesetting by Roy's Typesetting Service, New Orleans.

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Columbus, Ohio - 2-6 of August 1976

**The American
Malacological Union**





AMU '76 — COLUMBUS, OHIO

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AMERICAN MALACOLOGICAL UNION, INC.
Forty-Second Annual Meeting

Aug. 2 - 6, 1976

Columbus, Ohio

The Forty-Second Annual Meeting of the American Malacological Union was held on the campus of Ohio State University at Columbus, Ohio, August 2 - 6, 1976, with 129 members registered.

Members began to arrive early on Sunday, Aug. 1, checking in at Blackburn House Dormitory on campus. Registration was smoothly accomplished that day and on Monday, allowing members to have ample time to visit in the lobby and to roam the campus area to sample restaurants. AMU had Blackburn all for its own members, overflowing to the next dormitory also.

Monday afternoon a conservation meeting was called for those interested.

The first scheduled event was a trek to Black Forest Inn, a campus gathering place, for a very informal get-together on Monday before the opening session at 7:15 p.m. at Independence Hall.

Dr. Dorothea Franzen, president, opened the session with a warm welcome and presented Dr. David Stansbery, director of the Museum of Zoology of the Ohio State University, who introduced Dr. Richard H. Bohning, dean of the College of Biological Sciences at OSU.

Papers of the evening were on land and fresh water mollusks, with a tribute to Dr. Victor Sterki and notes from some of his correspondence. The stress on fresh water and land mollusks was thus well established for this meeting.

Members from Texas rounded out the evening by inviting everyone to the basement recreation room at Blackburn House for an hour or so of friendly talk and song.

Tuesday the meeting sessions began at Hitchcock Hall, starting at 8:45 a.m. The group photograph was accomplished at noon with members seated in the comfortable seats. No sun glare this time!

Members of the conservation committee and interested members met in the cafeteria at lunchtime to formulate recommendations to Council.

The afternoon session featured papers on a wide variety of subjects, ending in time for

everyone to dash to have the evening meal at the campus cafeteria. Council met that night in the Executive Office of the Museum of Zoology. The conservation committee held another meeting before sending in recommendations to Council. Other AMU members were afforded the opportunity to visit the Museum of Zoology where members of the staff opened drawers of catalogued mollusks and answered questions for some of our members having their first chance to visit such a research collection. All those visiting the Museum were impressed with the stacks of preserved fresh water and land material for research being put together by Dr. Stansbery, Dr. Carol Stein and staff members. The move back to Sullivant Hall at 1813 N. High Street has just recently been accomplished. The rows of cases and the collection of "wet" specimens were impressive.

A full quota of papers on Wednesday morning moved along with good timing by the moderator, Dr. Katherine V.M. Palmer was in attendance for the first time in recent years and presented some unpublished plates of Lamarck from a rare series of Eocene and living mollusks. These are due to be published, with the reprinted text.

The afternoon's session was requested and planned by President Franzen and moderated by Dr. Harold Murray. The Symposium on the Current Trends in Malacology featured a number of selected subjects to stir interest from amateurs and professionals.

That evening a FIRST for AMU was a highly successful and popular Literature Auction, with Morris Jacobson as auctioneer. Members swarmed over the tables of sale books and reprints and even bid against themselves in eagerness to acquire the auction materials, all of which were donated to AMU for this event. Slides from the new exhibit on mollusks at the American Museum of Natural History in New York City were shown also.

Thursday's sessions were full to the brim with papers. However, the schedule was adhered to very well, and the annual business meeting at

3:30 p.m. lasted approximately an hour, giving everyone time to relax and dress up for the social hour and annual banquet at the OSU Faculty Club. After quite a sumptuous feast, members retired to a meeting room to hear commentaries and see slides on marine bivalves by Dr. Thomas R. Waller. Dr. Franzen presented her officers and committees and introduced an impressive number of former AMU presidents. The gavel was handed over to Dr. George Davis. Officially, AMU ended this annual session.

The weather in Columbus had been ideal the whole week. The sun had shown brightly every day, and nights had been so cool that the dormitory staff had had to provide blankets for us sleeping in single bunk beds. However, the morning after the banquet dawned with rain and heavy clouds. This was the day set for the field trip. Some twenty cars of members started off for

the first of three sites, but only about six ended up at the final stop. We had lunch in the rain at a lakeside park, but it didn't seem to matter too much to those who figured they would get wet anyway collecting land and fresh water mollusks. We scrambled through a bog to get fresh water snails, collected snails and fossils as we slid and slithered down a river bank, and we waded Little Darby Creek to dig around the water willows. One amateur participant saw a snake and gave up. Another stuck it out, wearing a plastic garment bag to ward off the rain. All faced going back to the dorms and checking out in heavy rain. Parts of Columbus were flooded that day. AMU members didn't seem to mind. The 42nd annual meeting had been too good a meeting to damper their spirits.

Constance E. Boone

CONTRIBUTED PAPERS PRESENTED AT THE 1976 MEETING

SPHAERIIDAE NATALITY AND ITS SIGNIFICANCE IN WATER QUALITY STUDIES

G. L. Mackie

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Benthic indicator organisms and diversity of aquatic invertebrate communities are common methods used in the assessment of water quality. However, these methods often employ quantitative techniques with deficiencies that introduce substantial errors in population estimates; there are no sampling devices that sample all substrates and all communities equally well, some size classes of organisms are often lost in washing procedures, and there are no techniques for separating *all* the benthic organisms from a sample of substrate. There are many other sources of error and investigators are constantly trying to devise new techniques that will improve quantitative estimates of benthic populations.

Rather than devising new quantitative sampling techniques we are using natality data which requires only a sufficient number of organisms for determining the numbers of young produced by individuals or by a unit of population. Natality is described here as realized natality - the amount of successful reproduction that actually occurs over a period of time (Smith 1974). It is influenced by environmental conditions, nutrition, population density, mortality and competition. Natality is measured as a rate and may be expressed either as crude birth or specific birth rate. Crude birth rate is expressed in terms of population size (Smith 1974), as for example 50 young/growth container/month. Specific birth rate is expressed relative to a specific criterion, as for example 50 newborn/month/length class x.

Natality rates are more easily determined for some animals than for others. Sphaeriids are ideal organisms for study because they are cosmopolitan and, most important, are ovoviviparous. The orderly development of larval stages in brood sacs (Mackie, Qadri, & Clarke 1974) facilitates relatively simple enumeration of larvae. Most other benthic organisms are oviparous making it very difficult to determine natality rates.

The use of sphaeriid natality as an index of environmental stress is a new concept. However, before its use can be assessed the effects of other environmental parameters on sphaeriid fecundity

must be known, especially temperature, sediment properties, population density, and competition which are functional in most benthic communities. The purpose of this paper is to examine the effects of these parameters and common environmental pollutants such as sulfate, road salts, pulp and paper wastes, and raw sewage and slaughterhouse wastes on the natality of a sphaeriid using controlled laboratory and field experiments.

MATERIALS AND METHODS

Musculium securis was used as the test animal because it is easy to maintain in the laboratory and grows and reproduces relatively quickly (60 - 80 days). With few exceptions, newborn *M. securis* were obtained from Carp Pond (Mackie, Qadri, & Clarke 1976) and grown in 100 mm diameter X 50 mm height "Pyrex" dishes containing 50 g air-dried soil, 2 g air-dried black willow or white elm leaves, and distilled or deionized water to capacity of each dish. After allowing one day for equilibration, 5 pre-measured newborn *M. securis* were added to each dish. Three replicates were made for each magnitude of environmental parameter tested. The parameters examined in the laboratory were temperature (5C, 10C, 18C, 25C), sediment texture (particle sizes of

0.05 mm i.e. silt and clay, 0.050-0.125mm fine sand, 0.125-0.50mm i.e. medium to fine sand, and 0.50-2.00mm i.e. coarse to very coarse sand), different sediments and leaves (see Table 1 for different combinations of sediments and leaves used), population density (5, 10, 20, 30, 40 parents per dish), sulfate (0, 20, 40, 60, 80, 100, 200, 300, 400, 500 mgSO₄/l), and road salts (rock salt, pure sodium chloride, and calcium chloride in concentrations of 200, 400, 600, 800, 1000 mg/l). The parameters examined in the field were competition and industrial and municipal wastes. Growth tubes were used to maintain *M. securis* in the field (Mackie 1973). The effects of competition on sphaeriid natality were determined for *M. securis* and *M. transversum* in Britannia Bay of the Ottawa River near Ottawa, Canada. The densities used (Table 2) were based

TABLE 1

Mean natalities of *Musculium securis* adults showing the effects of the abiotic factors, temperature, sediment textures, and different kinds of leaf and sediment substrates. Means

side-scored by the same line are not significantly different at $P = 0.05$. Standard deviation of the mean in parenthesis. 5 pre-measured newborn in each dish at start.

Variable		Mean Nativity	Variable		Mean Nativity
Temperature (C)	per growth dish		Sediment Texture	per growth dish	
25	14.7 (3.1)		Fine sand	21.3 (3.1)	
18	49.7 (4.2)		Silt-clay	19.7 (3.5)	
10	0		Medium fine sand	4.7 (1.5)	
5	0		Very coarse sand	1.0 (1.7)	
			Sediment only	0	
			Leaves only	0	
Different Leaves	per growth dish		Different Leaves on Sediments	per growth dish	
Elm	40.3 (6.8)		Spruce on birch-aspen	44.0 (2.7)	
Cedar	40.7 (5.0)		Willow on willow-elm	42.0 (5.3)	
Willow	38.3 (4.2)		Oak on oak-maple	35.3 (5.7)	
Oak	34.0 (1.7)		Aspen on birch-aspen	11.0 (3.6)	
Birch	31.3 (8.3)		Maple on oak-maple	7.3 (1.2)	
Spruce	29.0 (4.4)		Birch on birch-aspen	7.0 (4.6)	
Aspen	27.3 (4.0)		Cedar on cedar	5.7 (1.5)	
Maple	5.3 (2.3)		Spruce on spruce	0	
No leaves	0				

on natural population sizes in Britannia Bay. The effects of industrial and municipal effluents were determined by placing twenty growth tubes, each containing one newborn *M. securis* from Britannia Bay, at distances of 50 m, 330 m, 700, and 1000 m below the outfalls of a pulp and paper plant and immediately upstream of the outfalls (= control); twenty tubes were also placed 1.6 km below a slaughterhouse and several raw sewage outfalls with the growth tubes placed in Britannia Bay as controls. The number of young produced by parents in each tube was recorded at the end of the experiment. Details of these materials and methods may be found in Mackie (1973).

RESULTS AND DISCUSSION

Tables 1 to 3 show that some levels of each environmental variable tested have a profound effect on the natality of *M. securis*. Environmental stress is indicated where natality rates are

significantly less ($P < 0.05$) than in control dishes. Table 1 shows that of the magnitudes tested, significantly smaller natalities occurred in the laboratory growth dishes kept at 25C and at less than 10C, in sediments coarser than 0.125 mm, and generally on sediments and leaves characteristic of the coniferous forest region.

On the basis of the numbers of reproductive adults in the population density experiments, the carrying capacity of the growth dishes was approximately 16 parents. Table 2 and Fig. 1 show that natality rates were significantly smaller in dishes maintained above carrying capacity and where intraspecific (compare a with b and e, and m with n and p, Table 2) and interspecific competition (compare c and l, d and k, f and j, g and i, and o and q, r and w, s and v, t and x, Table 2) were present.

Of the concentrations of pollutants tested, significantly smaller natalities occurred in concentrations greater than 100 mgSO₄/l, 200 mg

TABLE 2

Mean natalities of *Musculium securis* adults showing the effects of the biotic factors, population density and competition. Means side-

scored by the same line are not significantly different at $P = 0.05$. Standard deviation of the mean in parentheses.

Variable	Mean Natality		Variable	Mean Natality	
Density per dish	Per	dish			
5					
10	47.0	(3.6)			
20	63.0	(2.5)			
30	66.3	(3.0)			
40	71.3	(2.7)			
	73.7	(3.7)			
Competition	Per parent		Competition (cont'd)	per parent	
<i>M. securis</i> :			<i>M. securis</i> :		
<i>M. transversum</i>	<i>M. securis</i> only		<i>M. transversum</i>	<i>M. transversum</i> only	
a 1:0	9.8	(2.4)	m 0:1	11.8	(3.2)
b 10:0	7.0	(0.3)	n 0:10	9.5	(0.3)
c 9:1	7.2	(0.6)	o(=1) 1:9	9.3	(0.7)
d 19:1	4.5	(0.8)	p 0:20	6.4	(0.4)
e 20:0	4.5	(0.4)	q(=c) 9:1	6.3	(0.6)
f 16:4	4.7	(1.0)	r(=j) 4:16	6.0	(0.8)
g 18:2	4.4	(0.5)	s(=i) 2:18	6.0	(0.4)
h 10:10	3.4	(0.8)	t(=k) 1:19	6.1	(0.9)
i 2:18	2.3	(2.1)	u(=h) 10:10	4.4	(0.3)
j 4:16	2.2	(0.5)	v(=g) 18:2	0.7	(1.2)
k 1:19	2.3	(0.6)	w(=f) 16:4	0	
l 1:9	1.7	(1.5)	x(=d) 19:1	0	

NaCl/1, and less than 600 mgCaCl/1 (Table 3). River water contaminated with pulp and paper wastes and with raw sewage and slaughterhouse wastes (Mackie 1973) also significantly reduced natality rates of *M. securis* (Table 3).

The results of these studies indicate that the natality of *M. securis* is either directly or inversely related to the intensity of environmental variables, especially pollutants. This implies that the natality of *M. securis* and other sphaeriids is potentially a good index of environmental stress. However, before natality of other sphaeriid species can be used as an index of water quality, the effects of various pollutants must be determined for several species since some e.g. *Sphaerium striatinum* respond to slight fertilization by increased productivity (Ingram *et al* 1953) and others e.g. *M. securis* by decreased productivity. Also, because of the heterogeneity of the natural habitat and the multiplicity of

factors (e.g. temperature, sediment texture, competition, etc.) which operate through factor interaction, experiments should be done in the field on natural populations. Stations should be established above (= control) and at several distances below the outfalls. Habitat characteristics should be similar, except for those features altered by pollution, and natalities compared with those in the control station. It is essential that a control station be established because natalities may vary from one year to the next and among different bodies of water (Mackie, Qadri, & Clarke 1976).

If these criteria are met, then any changes in water quality would be accompanied and be detected by changes in the natality index. Values significantly less than those obtained in the control station would indicate an aggravation in water quality. Values significantly greater than those obtained in the control station would

TABLE 3

Mean natalities of *Musculium securis* adults showing the effects of sulfate, rock salt, sodium chloride, calcium chloride, pulp and paper waste and raw sewage and slaughterhouse wastes.

Means side-scored by the same line are not significantly different at $P = 0.05$. Standard deviation of the mean in parentheses.

Variable	Mean Natality		Variable	Mean Natality	
Sulfate mg/l	per growth dish		Rock Salt mg/l	per growth dish	
40	52.0	(9.2)	0	54.3	(5.1)
20	43.1	(7.0)	200	33.7	(2.5)
0	43.6	(5.6)	400	19.3	(3.2)
60	43.3	(9.2)	800	8.3	(2.7)
80	40.7	(1.2)	600	3.0	(1.5)
100	39.7	(0.6)	600	0	
200	21.0	(15.6)	1000		
300	10.7	(2.9)			
400	10.3	(5.7)			
500	0				
Pulp and Paper	per growth tube		Sodium Chloride mg/l	per growth dish	
Above outfalls	3.8	(1.6)	0	54.3	(5.1)
1000 m below	2.1	(0.6)	200	28.7	(2.1)
700 m below	1.8	(1.1)	400	22.0	(7.6)
300 m below	0.8	(1.3)	600	8.7	(4.1)
50 m below	0		800	5.0	(5.6)
			1000	0	
Sewage and Slaughter	per growth tube		Calcium Chloride mg/l	Per Growth Dish	
Above outfalls	9.8	(2.4)	0	54.3	(5.1)
Below outfalls	0		800	40.7	(8.1)
			600	31.3	(5.1)
			1000	30.3	(7.5)
			200	28.7	(2.1)
			400	22.0	(8.5)

indicate that the species responds to the ambient conditions by increased productivity. The habitat that supports the highest natality would probably be the habitat most characteristic of the species. Therefore, if a species is more prolific in organically enriched areas, it is probably an indicator of those conditions.

Applying the index to the Ottawa River, the highest natality (2.44) in the natural population of

M. securis in 1972 was obtained in Britannia Bay, the control station. The mean natality of *M. securis* below the pulp and paper outfalls was 1.70 newborn per parent. This was significantly less than that obtained in Britannia Bay, indicating an aggravation in water quality.

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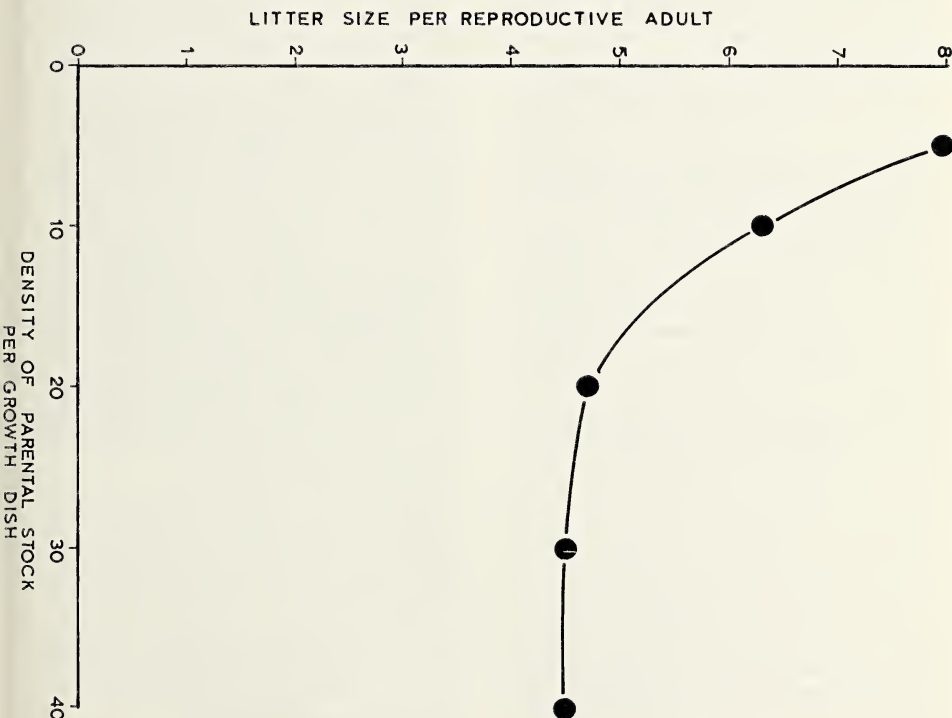


Fig. 1 - Relation between the average litter size per reproductive adult and the density of parental stock of *M. securis* in laboratory growth dishes. Curve was fitted by eye.

SPECIES OF THE GENUS *UNIOMERUS*

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The genus *Uniomereus* Conrad, 1853 (p. 268), originally included the species *declivis* Say, *camptodon* Say, *subcroceus* Conrad, *sayi* Ward, *rivularis* Conrad, *porrectus* Conrad, *symmetricus* Lea, and *excultus* Conrad. According to the International Code of Zoological Nomenclature, the type-species of the genus must be one of these originally-included names.

Simpson (1900, p. 739) stated that *Unio tetralasmus* Say was the type of *Uniomereus*. However, since *tetralasmus* is not one of originally included names, it cannot be recognized as the type-species. In the synonymy of *U. tetralasmus*, Simpson listed *excultus*, *subcroceus*, and *symmetricus*, all of which were among the names originally included by Conrad. According to Article 69 (a) (iv) of the International Code, "If an author designates (or accepts another's designation) as type-species a nominal species that was not originally included, and if, but only if, at the same time he synonymizes that species with one of the originally included species, his act constitutes designation of the latter as type-species of the genus." Because Simpson synonymized under *tetralasmus* not just one but three of the originally included species, his act cannot be construed as the designation of any one of the three as type-species.

In the same way the reverse synonymy of Ortmann (1912, p. 272) in putting *declivis* and six other so-called species as synonyms or varieties under *tetralasmus* which he declared to be the type, does not hold. We now know that *tetralasmus* and *declivis* are separate species. The first clear designation of *declivis* Say, 1832 as the type-species is that of Frierson (1927, p. 10).

Three species can be recognized in the genus *Uniomereus*. They are separable not only on the basis of shell characters, but also on zoogeographic and anatomical grounds. Their exact time of reproduction, details of glochidial shape and structure, and fish host species are still unknown.

Uniomereus carolinianus (Bosc, 1801)

Unio caroliniana L.A.G. Bosc, 1801, Histoire Naturelle Des Coquilles, Deterville edition, Paris,

vol. 3, p. 142, pl. 23, fig. 2; refers to Tableau Encyclopédique et Méthodique, pl. 239 (249), fig. 5 ("Se trouve dans les eaux dormantes en Caroline"); 1824, *ibid.*, p. 139.

Synonyms: the following names are here considered synonyms of *U. carolinianus* Bosc, and are listed by name, author and date only. For full citations of references see Johnson (1970:339-340): *Unio obesus* Lea, 1831; *U. buddianus* Lea, 1843; *U. paludicolus* Gould, 1845; *U. ineptus* Lea, 1852; *U. columbensis* Lea, 1857; *U. plantii* Lea, 1857; *U. cicur* Lea, 1861; *U. squalidus* Lea, 1863; *U. bissealianus* Lea, 1867; *U. jewettii* Lea, 1867; *U. pawensis* Lea, 1868; *U. rivicolus* Conrad, 1868.

Simpson (1900; p. 741) was correct when he observed that *carolinianus* "is quite probably *U. obesus*." However, his decision to use Lea's later name was not in accordance with the present international rules, which state that the earliest valid name is the one to be used for a species.

In Bosc's introduction he observes that a species of *Unio* [probably *U. carolinianus*] was found living in mud which was dried so hard it could not be broken with a spade, and which was only watered by the occasional rains of the summer months. Any species found in such a habitat could only be a member of the genus *Uniomereus*. It could not possibly be a *Margaritifera*, nor could it be a synonym of *Elliptio complanatus*, as I had considered it until I read Bosc's description of its habitat.

This is the *Uniomereus* of the Atlantic drainage. It is presently known from North Carolina southward all the way around Florida, to and including the Flint River system of Georgia. Its reported presence in southern Virginia needs confirmation.

This species, like *U. declivis* from Ohio, has both male and female individuals, in approximately equal numbers, according to the gill structure of specimens I have examined.

Uniomereus declivis [Say, 1932]

Unio declivis Say, 1831 [1832] Transylvania Journal of Medicine vol. 4, p. 527 (Bayou Teche,

Louisiana); 1832, American Conchology no. 4, pl. 35.

Synonyms: (see Johnson, 1970): *Unio campton* Say, 1832; *U. geometricus* Lea, 1832. *U. excultus* Conrad, 1838; *U. sayii* Ward (in Tappan), 1839; *U. parallelus* Conrad, 1841, non Sowerby, 1840; *U. symmetricus* Lea, 1845; *U. rivularis* Conrad, 1853; *U. porrectus* Conrad, 1854; *U. manubius* Gould, 1855.

This species differs from *tetralasmus* by having a much more distinct point at the posterior base, and by the fact that males and females occur in approximately equal numbers. Frierson (1903) has discussed the differences between the shells of these two species in detail, with illustrations.

The species *declivis* Say is recorded from the Lake Erie drainage, Ohio and Indiana; from Tennessee; from the Coosa River system in Alabama, and southwest across Texas to the south side of the Rio Grande system in Chihuahua, Mexico.

Uniomers tetralasmus (Say, 1831)

Unio tetralasmus Say 1831, American Conchology, no. 3, pl. 23. (Bayou St. John, near New Orleans [Louisiana]).

Synonyms (see Johnson, 1970): *Unio blandinianus* Lea, 1834. *U. hebes* Lea, 1852. *U. subcroceus* Conrad, 1854; *U. jamesianus* Lea, 1857.

Unio tetralasmus has a much more rounded posterior end than *U. declivis*. It is only in some of the oldest specimens, when the shells become markedly arcuate, that it becomes quite difficult to separate the two species. In contrast to the dioecious species *declivis*, *tetralasmus* individuals all possess the female type of gill structure, and hence are evidently either parthenogenetic or

hermaphroditic.

This species occupies much the same geographic area as *U. declivis*. I have seen specimens from Lake Erie, Ohio; from Indiana, Illinois, Tennessee, Mississippi, and south to the Coosa River drainage in Alabama, and in the west from Colorado, Nebraska, Missouri, Kansas, Oklahoma, Arkansas, and Texas.

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VARIATIONS in APERTURE CHARACTERISTICS
of
EIGHTEEN SPECIES of UNIONIDAE
from
LAKE ERIE

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Anatomical data pertaining to the soft parts of North American naiades (Unionidae) have been published almost since the discovery of the fauna. Rafinesque (1820) published figures of two species illustrating gills, palps, mantle lobes and foot, and the visceral mass arrangement. Barnes (1823), Kirtland (1834), Agassiz (1851), and Lea (1859) all stated the importance of soft anatomy in naiad classification. George B. Simpson (1884) was the first to do a detailed study of the anatomy of a North American naiad.

Near the beginning of the twentieth century, students such as Sterki (1895, 1898) and C. T. Simpson (1900) began to utilize soft parts in naiad systematics. Ortmann (1910, 1911, 1912) built upon and expanded this trend. These authorities chose to use both soft part features and shell characteristics in classification and phylogeny. As a result, most of the "higher" classification (i.e. genera, subfamily, family, super-family, etc.) is currently based on soft anatomy while species and subspecies are based on shell characters. On the species level the soft part descriptions often were qualitative terms such as "large," "normal," etc. (Baker 1898).

Modern workers recognize the exhibition of both genetic and environmental variation in a species' shell structure but, until recently, have done very little in this regard with the soft parts. Recent work by Kraemer (1970), Fuller and Bereza (1974), and Kokai (1974) has only begun to quantitatively explore this variation. This study deals with the variation of the number, size, and arrangement of the papillae of the incurrent apertures of 18 species of naiades from one community in western Lake Erie. The intent of this study was to determine what soft part variation exists among, and within, the species of western Lake Erie.

The approximately 800 specimens used in this study were collected during the summer of 1970 from Fishery Bay of Lake Erie between South

Bass and Gibraltar Islands, Ottawa Co., Ohio. This area was chosen because of the great abundance of naiades, the relatively large number of species, and its proximity to the Stone Laboratory of the Ohio State University. Specimens were preserved in a solution of 75% ethanol, 20% water, and 5% glycerin. This preservative somewhat alters the appearance of the soft parts because of some tissue contraction, dissolving of pigment, etc. The descriptions below, however, refer to specimens which were preserved exactly the same way and yielded consistent results in this type of solution. Observations of papillae were made using a binocular microscope at magnifications between 16x and 60x.

TABLE I

Species Collected	Number of Specimens
1) <i>Anodonta grandis grandis</i> Say, 1829	5
2) <i>Quadrula quadrula</i> (Rafinesque, 1820)	6
3) <i>Quadrula pustulosa</i> (Lea, 1831)	28
4) <i>Amblema plicata plicata</i> (Say, 1817)	156
5) <i>Fusconaia flava</i> (Rafinesque, 1820)	92
6) <i>Cyclonaias tuberculata</i> (Rafinesque, 1820)	3
7) <i>Pleurobema coccineum</i> (Conrad, 1836)	40
8) <i>Elliptio dilatatus</i> (Rafinesque, 1820)	88
9) <i>Ptychobranchus fasciolaris</i> (Rafinesque, 1820)	6
10) <i>Obliquaria reflexa</i> (Rafinesque, 1820)	5
11) <i>Obovaria subrotunda</i> (Rafinesque, 1820)	7
12) <i>Truncilla truncata</i> (Rafinesque, 1820)	6
13) <i>Leptodea fragilis</i> (Rafinesque, 1820)	55
14) <i>Potamilus alatus</i> (Say, 1817)	108
15) <i>Ligumia recta</i> (Lamarck, 1819)	8
16) <i>Ligumia nasuta</i> (Say, 1817)	8
17) <i>Lampsilis radiata luteola</i> (Lamarck, 1819)	149
18) <i>Lampsilis ventricosa</i> (Barnes, 1823)	6

All species collected (Table 1) had papillae lining the margin of the incumbent aperture. Although many additional variations exist, the papillae of Lake Erie species were of four basic types. 1) TENTACULATE - elongated, solitary structures with a relatively uniform diameter from base to tip (Figure 1); 2) CONICAL - solitary papillae in which the diameter is obviously greater at the base; 3) BIFURCATED - papillae having two tips arise from the same base; 4) AGGREGATED - papillae in which more than two tips arise from a mutual base (Figure 2). Many species have combinations of, or slight deviations from, these four basic types. Several types of variation occurred among different specimens of the same species. First, the smaller, and presumably younger, specimens usually had fewer and smaller papillae than the larger specimens. Secondly, if a species had papillae which bifurcated or split, the bifurcations were more numerous in the larger specimens. These variations imply that, at least for some species from Lake Erie, the morphology and number of papillae change with age. The increase in papillae number is more readily observed when a large sample size is available. Table 2 shows variation in papillae number with an increase in animal size for 156 specimens of *Ambelma plicata*

TABLE 2

Animal Size	Number of Specimens	Papillae Number
40-49 mm	2	18 - 31
50-59 mm	6	30 - 52
60-69 mm	28	40 - 63
70-79 mm	45	39 - 84
80-89 mm	39	54 - 86
90-99 mm	30	66 - 97
100-109 mm	2	90 - 101
110-119 mm	4	110 - 132

Table 2. Number of papillae of the right side of the incumbent aperture of *Ambelma plicata plicata* (Say, 1817) versus increase in animal size. In general, as the animal gets larger, the number of aperture papillae increases.

plicata (Say, 1817). It should be noted that these data, although typical, are not necessarily representative of papillae numbers for other Lake Erie species. Third, in some species the papillae, or clusters of papillae, were distinctly "ranked" in rows along the periphery of the aperture, but in other species the papillae were randomly distributed. A short description of the papillae of the incumbent apertures follows.

Anodonta grandis grandis Say, 1829.

Papillae in smaller specimens appear to be two-ranked with the inner papillae tentaculate and the outer papillae a short protuberance. In larger specimens the papillae of both ranks are more-or-less equal in length with less distinction of the rows. Bifurcations of the papillae occurred in only one specimen.

Quadrula quadrula (Rafinesque, 1820).

Most papillae are joined into distinct assemblages with as many as 23 papillae tips per cluster. The clusters are singly ranked along the aperture margin and vary in number in size. Solitary papillae may occur between, and lateral to, the larger clusters. The individual papillae are shorter than the aggregated clusters and sometimes bifurcate.

Quadrula pustulosa (Lea, 1831).

The papillae of *Q. pustulosa* are arranged in the most distinct assemblages of all the species from Lake Erie. The aggregated papillae are two-ranked, subequal in length, and have between 10 and 19 papillae tips per cluster. There are very few solitary papillae between the clusters or on the lateral edge of the aperture margin.

Ambelma plicata plicata (Say, 1817).

The papillae of this species are the most variable in arrangement of all species observed. In a few specimens the papillae were solitary and bifurcating but in most specimens they were solitary conical or tentaculate. The smaller specimens generally had short, two-ranked protuberances and the larger specimens had elongated papillae distributed randomly along the periphery of the aperture. Aggregated papillae were not seen.

Fusconaia flava (Rafinesque, 1820).

Papillae are aggregated as in the genus

Quadrula. The papillae were small, of equal length, and numbered as many as 30 per cluster. The aggregations are two-ranked with the larger clusters medial. Shorter, solitary, non-bifurcating papillae are common throughout the entire lateral periphery of the aperture.

Cyclonaias tuberculata (Rafinesque, 1820).

Aggregate papillae arise from a mutual base but very short, bifurcating papillae occur between, and lateral to, the clusters. Aggregated papillae have five or six tips per group. The clusters may be two or three ranked and are smaller near the dorsal and ventral extremes of the aperture.

Pleurobema coccineum (Conrad, 1836).

Structure and arrangement basically the same as for *Fusconaia flava*. The number of papillae per cluster is much less however, with usually no more than six tips per assemblage.

Elliptio dilatatus (Rafinesque, 1820).

Papillae are solitary and may be two or three ranked around the perimeter of the aperture. Those of the lateral ranks are shorter. The larger specimens have longer papillae of more equal length arranged so that the ranking is obscured.

Ptychobranthus fasciolaris (Rafinesque, 1820).

Young specimens have papillae which are subequal, two-ranked, solitary protuberances. Older specimens have papillae slightly more elongated into a cone shape with the height of the cone being approximately three times as great as the base.

Obliquaria reflexa (Rafinesque, 1820).

Papillae are solitary, contiguous, and tentaculate. No ranking could be determined. The papillae are slightly smaller at the dorsal and ventral extremes of the aperture. There are no bifurcations.

Tuncilla truncata (Rafinesque, 1820).

Papillae are gathered into a contiguous mass. All are tentaculate with no bifurcations. They are equal in length throughout most of the margin of the aperture but a few shorter papillae are near the dorsal and ventral extremes.

Leptodea fragilis (Rafinesque, 1820).

L. fragilis has relatively large papillae which

are few in number. Individual papillae are very conical and are very close together.

Potamilus alatus (Say, 1817).

Two types of papillae are about equally numerous. Half are conical solitary structures which are about four times as long as they are wide. Half are aggregates with two, three, or four papillae tips. The solitary papillae are more common at the dorsal and ventral extremes of the aperture.

Ligumia recta (Lamarck, 1819).

The papillae are subequal, single ranked, conical and contiguous. The length of each is about four or five times its width. Bifurcations occur in a few papillae of one specimen.

Ligumia nasuta (Say, 1817).

Papillae of equal length, without ranking, and tentaculate. Length of each about five times its width. Papillae are slightly more numerous than in *L. recta* and have no bifurcations.

Lampsilis radiata luteola (Lamarck, 1819).

Subequal, tentaculate papillae are three ranked in younger specimens but more randomly distributed in older. Bifurcations and splitting of the individual papillae is common. Length of each is about six times the width. Bases of some of the papillae are fused in some specimens.

Lampsilis ventricosa (Barnes, 1823).

Papillae are two or three ranked, some fused at the base, conical or Y-shaped bifurcations, and subequal in length. The base is very broad with small papillae tips. The tips are about one third as long as the entire structure of the papillae.

The species of naiades from Lake Erie demonstrated considerable variation in number, size, shape, and distribution of papillae along the margin of the incurrent aperture. The most obvious difference among the species was the aggregation of individuality of papillae. With the exception of *A. plicat* all members of the subfamily Amblesinae had aggregated papillae. *Potamilus alatus* was the only species outside the Amblesinae that had aggregated papillae. Further study of the soft parts of other species, Lake Erie species found in streams, and additional specimens of species represented by inadequate sample size, is needed before the value of

apertural structures in naiad classification can be determined with certainty.

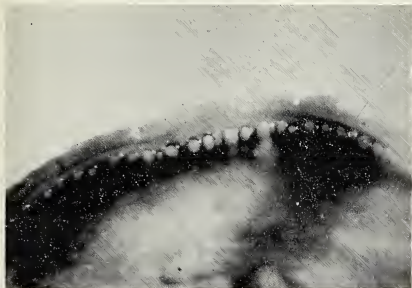


Figure 1. The papillae of *Elliptio dilatatus* (Rafinesque, 1820). These papillae are characteristic of the solitary, tentaculate type in which the diameter is uniform from base to tip. (x 30)

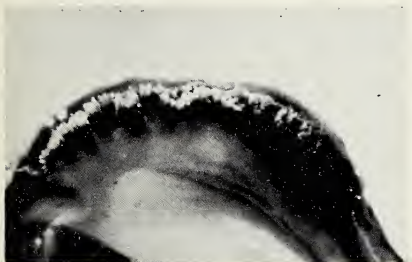


Figure 2. Aggregated papillae of *Quadrula quadrula* Rafinesque, 1820 (x 16). The characteristic of aggregated papillae is several tips arising from a mutual base.

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CHROMOSOME NUMBERS OF SOME NORTH AMERICAN NAIADES
(Bivalvia: Unionacea)

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Within the last two decades an increasing number of biologists have been determining the chromosome number of various species and using this (and other chromosomal information) as an aid in classification. The rationale behind the use of chromosomal characters in systematics is that chromosomes provide information which is largely unaffected by environmental conditions. Additionally, genetic research has shown that changes in the number and morphology of the chromosomes can result in changes in the morphology and functioning of the organism.

In the Phylum Mollusca the chromosome numbers of approximately 0.5% of the species are known (Patterson, 1969), and the vast majority of these are gastropods. On the basis of the 23 pelecypod chromosome numbers compiled by Menzel (1968), he suggested that the chromosome number in all bivalves is a conservative feature of family-level groupings. This suggestion lent considerable weight to the study of the chromosomal characters in the naiades, a group of freshwater bivalves which is presently undergoing considerable revision at essentially all taxonomic levels. This project, now underway, is intended to determine if any of the several chromosomal characters can be used to improve naiad classification. This report, however, deals only with the most obvious chromosomal character—the number of chromosomes.

METHODS

The specimens used in this study so far have either been naiades collected for inclusion into the bivalve collection of the Ohio State University Museum of Zoology or were collected specifically for this project from streams near Columbus, Ohio. No conscious attempt has, as yet, been made to sample either the geographic or taxonomic diversity of naiades found in North America. Samples of labial palp or inner gill tissue were removed from the living animal, placed in a hypotonic solution and then fixed in freshly-mixed glacial acetic acid and absolute

methanol (Arrighi and Hsu, 1974). The fixed material was swabbed onto slides which were air-dried or flame-dried and then stained in 2% Giemsa stain. All slides examined were scanned at 200x and chromosomes were counted and photographed at 1000x using an Olympus phase-contrast microscope.

(It should be noted that, in its present form, this technique often yields no chromosome spreads at all. Under the best conditions produced so far, only a few chromosome spreads occur on any one slide. A brief experiment with the vertebrate mitotic inducer, phytohemagglutinin, failed to increase the number of spreads.)

RESULTS AND DISCUSSION

To date, fifteen North American naiad species have been examined in sufficient detail to justify the publishing of chromosome numbers (Table 1). These species include representatives of the two long-standing families Margaritiferidae and Unionidae and all three of the classic subfamilies of the Unionidae. The diploid chromosome number of all of these species is 38.

The geographic and taxonomic variety present in this assemblage seems to be sufficient to suggest that all North American naiades possess 38 chromosomes. The only published chromosome numbers for naiades based on whole cell preparations (Van Griethuysen et al., 1969) indicates that *Unio pictorum* and *Anodonta anatina* of Europe also have 38 chromosomes. [Lillie (1901) reported 32 chromosomes ($n = 16$) for *Elliptio complanatus*, however, his study was based on sectioned material.] While it is likely that there will be species found with atypical chromosome complements, it would not seem at all surprising if the vast majority of species in the Superfamily Unionacea were found to possess the same number of chromosomes — 38. Future research will either support or refute this prediction and, in addition, provide chromosomal evidence concerning the relationship of the Unionacea to the Mutelacea, the other Superfamily of large, strictly freshwater bivalves.

Table 1. Chromosome numbers of fifteen species of North American naiades. Also listed are the number of spreads which gave this chromosome count, the number of specimens of each species which provided these spreads and the locations from which these specimens were collected.

Species	Chromosome Number	No. Complete Spreads Counted	No. Animals Examined	Collection Site
Margaritiferidae				
<i>Margaritifera margaritifera</i> form <i>falcata</i>	38	8	1	Wilamette River, Oregon
Unionidae				
Anodontinae				
<i>Alasmidonta arcuata</i>	38	3	1	Ohoopsee River, Georgia
<i>Alasmidonta marginata</i>	38	8	1	Big Darby Creek, Ohio
<i>Anodonta grandis</i>	38	14	1	Buffalo Creek, Ohio
<i>Anodontoides ferussacianus</i>	38	12	1	Buffalo Creek, Ohio
<i>Lasmigona costata</i>	38	8	1	Big Darby Creek, Ohio
Unioninae				
<i>Gonidea angulata</i>	38	4	1	Wilamette River, Oregon
<i>Quadrula quadrula</i>	38	4	1	Big Darby Creek, Ohio
<i>Tritogonia verrucosa</i>	38	3	1	Big Darby Creek, Ohio
Lampsilinae				
<i>Lampsilis radiata luteola</i>	38	8	2	Big Darby Creek, Ohio
<i>Potamilus alatus</i>	38	5	1	Buck Creek, Kentucky
<i>Ptychobranchus fasciolaris</i>	38	3	1	Big Darby Creek, Ohio
<i>Toxolasma lividus glans</i>	38	3	1	Buck Creek, Kentucky
<i>Villosa iris</i>	38	11	1	Big Darby Creek, Ohio
<i>Villosa lienosa</i>	38	5	1	Buffalo Creek, Ohio

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ENDANGERED FRESHWATER MOLLUSKS OF NORTHWESTERN NORTH AMERICA

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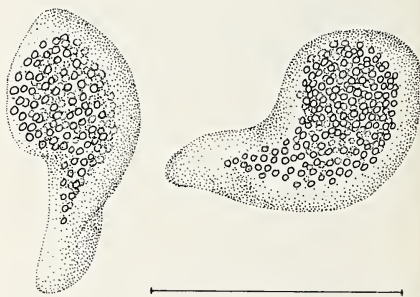
Recent field work by the writer and associates has shown that at least six species and subspecies of freshwater mollusks living in the northwestern United States and in western Canada are endangered. These were not cited in the Symposium on Rare and Endangered Mollusks presented at the 1968 A.M.U. annual meeting (published in *Malacologia* vol. 10, no. 1, 1970) and it therefore seems desirable that they be briefly discussed here. Other species in the region may be also threatened but more research is necessary before this can be determined.

Juga acutifilosa (Stearns, 1890) (Pleuroceridae), the Graceful Keeled Horn Snail, is a rather large (30 mm), slender and spectacular species with strong crenulated spiral keels and without any longitudinal plicae. It now occurs only in a single spring-fed pool (and in its outlet for about 100 yards downstream) located close to Willow Creek in Lassen County, northern California, southeast of Eagle Lake. Archaeological shells indicate that its distribution was previously much more extensive. The single locality where it now lives is accessible to cattle and is subject to alteration by the private owner if he wishes to do so.

It is of interest that *J. acutifilosa* deposits gelatinous egg masses resembling those of some freshwater pulmonates. One medium-sized specimen kept in the laboratory deposited an irregular subcylindrical and crescent-shaped egg mass about 10 mm long and 6 mm wide containing about 100 pale, turquoise-coloured eggs. (Fig. 1). Similar masses, larger than the one measured were observed in the field. These are quite different from the egg masses deposited by eastern pleurocerids and, if they are similar to those of other western species, they provide additional justification for the separation of western pleurocerids as a distinct genus.

Lithoglyphus columbiana (Pilsbry, 1899) (Hydrobiidae), the Great Columbia River Spire Snail, is a large (7½ mm) dark species with a conspicuous narrow shoulder on the body whorl and with the upper part of the body whorl

Fig. 1. Egg mass of *Juga acutifilosa* deposited in an aquarium. Scale line = 10 mm.



flattened and sloping to the rounded, almost basally located periphery. It apparently now survives only in the main channel of the Columbia River and only in the vicinity of the Hanford Atomic Energy Works in southeastern Washington. Because of damming this is the only free-flowing portion of the river remaining in the United States. If the river there is dammed or polluted the species will probably become extinct.

It formerly lived in the Spokane and Little Spokane rivers and downstream in the Columbia to its mouth. Until recently the species was known as *Fluminicola columbiana*.

Lanx nattall nattall (Haldeman, 1841) (Lancidae) the Giant Columbia River Limpet, is about 14 mm long, heavy-shelled, with an anterior apex located in the mid-line and an internal, ring-like muscle scar which gaps on the right side. It also appears to be presently restricted to the deep main channel of the free-flowing portion of the Columbia River in the vicinity of the Hanford Atomic Energy Works in southeastern Washington. Like *Lithoglyphus columbiana*, this species will probably become extinct if its only refuge is dammed or polluted. Its former range included

the Snake River from its mouth as far east as Rupert, Idaho and the Columbia River from its mouth upstream at least to Trail, British Columbia.

Physa johnsoni Clench, 1926 (Physidae), the Banff Springs Physa, is small (9 mm) inflated, with a short, flat-sided spire and in most specimens with white longitudinal and spiral streaks giving a cancellate appearance. Its previous range included several warm and cold springs in Banff National Park near Banff, Alberta but these springs have now been "developed" for the tourist trade and the snail now appears to be restricted to one small, rapidly-flowing, warm stream near Middle Spring, Banff, Alberta.

Physa jennessi atearni Clarke, 1973, the Blunt Albino Physa, is up to 7 mm long, with white shell and body, with a blunt spire and a dominant, peripherally flattened body whorl. It is known only from Johnson Lake and Horseshoe Lake both in Jasper National Park near Jasper, Alberta. Such lakes are often "improved" for fishing by poisoning them and then introducing trout. If this happens *P. jennessi atearni* will become extinct.

Physa species (undescribed), the Liard Hot Springs Physa, is small (5.5 mm), fragile, with flatly rounded whorls and a bluntly pointed apex. Its reproductive anatomy is distinctive and links it with a few other isolated species in the United States. It is known only from a ten-foot by one-foot cool vegetated portion of the outlet of Liard Hot Springs in extreme northern British Columbia near the Alaska Highway. If that spring is further "developed" the species will become extinct.

Full bibliographic references and other information on the species cited, except for the undescribed *Physa*, may be found in Taylor, 1975 and Clarke, 1973.

Field assistance was provided by the late Dr. D.G.S. Wright, the late Françoise Dehenne and my wife, Judith Clarke; laboratory assistance by Muriel F. I. Smith and Jane M. Topping and artistic support by Aleta Karstad Schueler who illustrated the egg mass of *J. acutifilosa*. Valuable information on *Juga acutifilosa* was contributed by Allyn G. Smith who also told me the location of the surviving colony. I am very grateful for all of this help. The author also wishes to thank the National Museums of Canada and the Office of Endangered Species, United States Department of the Interior, for providing funds for this work. A more detailed report giving precise localities will soon be on file at both institutions but such data are purposely kept vague in this paper to safeguard the populations concerned.

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THE EFFECT OF GRAVEL DREDGING ON MUSSEL PRODUCTION

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INTRODUCTION

The Tennessee Wildlife Resources Agency has been and now is concerned about the adverse effects of gravel dredging on the biota in the Tennessee River. This study was initiated and supported through the cooperative participation of the Tennessee Wildlife Resources Agency and NOAA, National Oceanic and Atmospheric Administration under PL88-309, Project No. 2-245-R.

The objectives of this study have been to find those methods and organisms that reveal best the effects of gravel dredging on the biotic communities. Many macrobenthic organisms and plankton were collected above and below the gravel dredging to compare their densities. Mussels were tagged, for the purpose of comparing growth rates and placed in areas above and below dredging. The best methods for measuring effects of gravel dredging were (1) use of tagged mussels as biological monitors and (2) use of a variety of artificial substrates which could be colonized with aquatic invertebrates. Growth differences of the mussels and different densities of the aquatic invertebrates above and below the dredging sites were recorded. A longer study period would validate the effects even better particularly since the gravel dredging is occurring along much of the length of the Tennessee River and each dredged area is different especially in water volume, rate of flow, and depth. Individual gravel dredging sites may reveal minimal effects in a short study but the total combined effect should be much more noticeable.

LOCATION OF STUDY

The primary study area was located at Tennessee River Mile 174 to 175 above Sallitto, Tennessee at Petticoat Riffle. This stretch of the Tennessee River averages 400 meters in width and 5 to 11 meters in depth except at Petticoat Riffle where the depth is 4 to 5 meters. Petticoat

Riffle is approximately 200 meters in length and 150 meters in width.

The suction gravel dredge picks up all the bottom material, carries it upward and then it is sorted to sizes and washed. The undesirable material is returned immediately to the river often leaving the bottom irregular and from one to several meters deeper than before the dredging. The wash water is also returned directly to the river leaving suspended solids in the water for some distance (depends upon particle size, rate of flow, and depth) below the dredge.

METHODS

Mussels were identified, aged, weighed, measured and marked before placement in study locations. Tagging of mussels was accomplished by using a metal template with 25 drill holes in it in rows of 5. The template was placed against the right or left valve and small drill holes, representing numbers, made on the shell surface. Using both right and left valves for marking surfaces almost 1500 mussels can be marked in one area. Each mussel was weighed in grams, and the length, height and width were measured in millimeters. The age was determined by counting the concentric growth rests. These mussels were returned directly to the river bottom. The location of these tagged mussels was determined by extending a line from a fixed point on the shore to the point out in the river where the mussels were actually placed.

One of the weaknesses of this placement method is the difficulty of relocating the organisms. Much time is required to measure, weight, mark and place these mussels in the selected sites and when they are lost much information is lost. Approximately 500 mussels were used to determine the effects of gravel dredging.

These mussels were collected from a large population at T.R.M. 170.3 located above Swallow Bluff Island in a clean gravel environment and where the water is relatively shallow and free flowing. The species selected was *Fusconaia*

ebena, which is the most dominant species now in the Tennessee River. It is commercially valuable in the cultured pearl industry. The species depends on the skipjack herring which is its host fish during its parasitic stages. A minimum of eight to twelve years is required for this mussel to grow large enough to be harvested and sold. These mussels may live and continue to grow for twenty or thirty more years in a good environment.

When water quality is good the species *F. ebena* may grow several times larger at a given age than others in a poor environment. Quality of habitat has a significant effect on growth rates of mussels, therefore the mussels selected were all members of a population in a specific area above Swallow Bluff Island. The original sizes and weights in age categories were nearly alike above and below the gravel dredge.

The marked mussels were placed in several locations to determine the effect of altered conditions on them. (1) Some were placed in an area immediately behind the dredge where the bottom had been altered by removal of several sizes of gravel. These mussels were gone when a search for them occurred. (2) Some were placed on the bottom at a previously dredged site along Wolfe Island; these had disappeared after one month. A second group of fifty to sixty marked mussels were again placed in that same location. A month later they were gone. (3) Some were placed below the gravel dredge where the bottom had not been altered but where the influence of suspended materials could be measured on the growth of the mussels. These were recovered after one year in this location and their weight and growth changes recorded. (4) Some were placed above the dredge and their location marked by one of the red buoy cans in the river. These were lost, however, because the red buoy was moved. (5) Another group was placed upstream in a habitat not influenced by silt or suspended materials and after one year these were collected, remeasured and reweighed.

The differences in weight increase and growth above and below the gravel dredge are rather large (Figs. 1 & 2). These differences are further magnified when one considers the total area of the Tennessee River affected, the total number of mussels involved and the life span potential for mussels.

The loose irregular bottom material in a dredged area will not support mussels for several

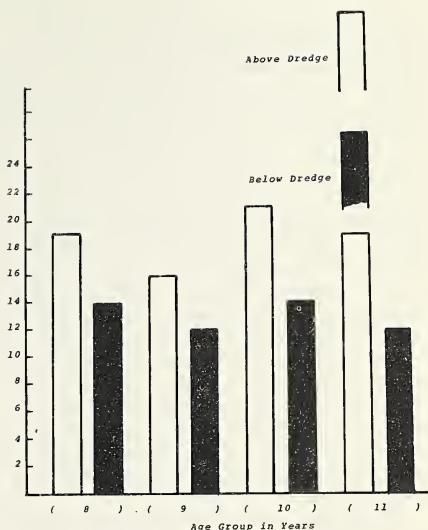


Figure 1. Mean percentage weight increase in *Fusconaia ebena* after one year.

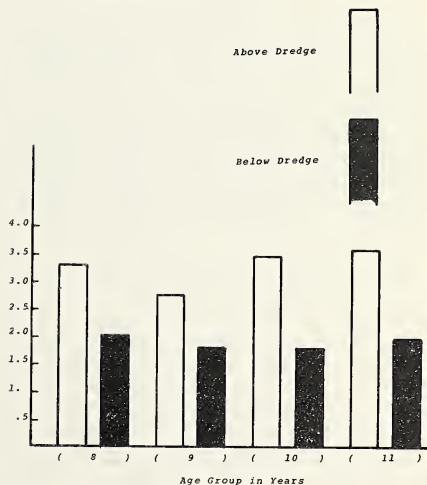


Figure 2. Mean shell growth of *Fusconaia ebena* millimeters per year.

months to years because it tends to shift. Also, the assortment of particle sizes is not immediately favorable for mussels, especially the first year stages. Since the bottom must first attract fish hosts carrying the larval mussels, it may be many years before a lost population of mussels returns to a dredged area. Mussel beds result from the host fish concentrating in an area. As the fish are feeding or spawning the metamorphosed mussels drop from their gills or fins and begin a free-living existence if the bottom is favorable. Then, for five or more years they go unnoticed while growing to about one inch in diameter. Another five years must elapse before they reach harvestable size for the cultured pearl industry. Whatever areas are dredged thus lose their mussel production for at least a decade. This is further amplified by the fact that these spawning areas are continuously being reduced and lost. Therefore, recovery time increases because the removed populations won't have neighboring populations from which the loss can be regained.

The ability to recover decreases after each environmental change and extends the potential time for recovery.

CONCLUSION

The resilience of the Tennessee River is not the same along its length nor are the organisms equally capable of reverting to their original densities.

Freshwater mussels are sedentary and have low resilience requiring much longer time to recover after a habitat alteration. Anything which causes the host fish of a mussel species to avoid or leave an area also eliminates the mussels. Many

of the fish species that serve as hosts to freshwater mussels are not tolerant to silt.

Mussels have had a prominent historical and economic significance in the Tennessee River. The ecological role of mussels has not been completely evaluated but it is known that the quality of water they inhabit is usually good. Mussels do filter suspended organic matter from the water and improve its quality for fish and other swimming forms. Mussels are natural food for muskrats, some aquatic birds and some fish.

The number of mussel species living in the Tennessee River today is less than half the number recorded fifty years ago. The remaining species are decreasing now even faster based on surveys made in the past few years. When a mussel species disappears the host fish species and many other interrelated organisms have probably disappeared.

RECOMMENDATIONS

1. Surveys and impact studies should precede any new gravel dredging sites in the Tennessee River and its tributaries. These impact statements should be presented to appropriate state game and fish agencies who, in turn, should take necessary action to preserve the fauna.
2. Biological monitors ought to be placed above and below gravel dredges in all areas of the Tennessee River to assess the intensity of the effect on the biota. Monitoring should occur on a continuing basis in order to compile data on the differences between the results at each dredging site.

PELECYPODS FROM THE KANOPOLIS LOCAL FAUNA (YARMOUTHIAN), ELLSWORTH COUNTY, KANSAS

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The Kanopolis local fauna includes a diverse assemblage of fossil vertebrates and molluscs that were collected by C. W. Hibbard and field parties from the University of Michigan Museum of Paleontology, during the summers of 1969, 1970 and 1971. A field party from Kent State University collected molluscs from this locality during the summer of 1971. The University of Michigan field parties were supported by N.S.F. grant GB-20249 to Dr. Hibbard; and the Kent State University field party was in part supported by a grant to the author from the K.S.U. Research Council.

The pelecypods were recovered from lenses of medium to coarse sand exposed in the SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 25, T15 S., R. 8 W., Ellsworth County, Kansas (Figure 1). The pelecypod fauna is of special interest because of: (1) the scarcity of Yarmouthian assemblages from the Pleistocene of Kansas; (2) the relative abundance and taxonomic diversity of the unionids; and (3) its implications concerning the drainage history of the Smoky Hill-Kansas system. Study of many of the various faunal elements is in progress, but completed reports are now available for the

amphibians, reptiles (Holman, 1972) and fish (Neff, 1975). The gastropods are now being studied by Mr. W. Terrance Kay, Kent State University, and the pelecypods are the subject of this paper. This report is based on all of the identifiable unionid material (88 valves), but only a small part (+ 550 valves) of the sphaeriids in the collections.

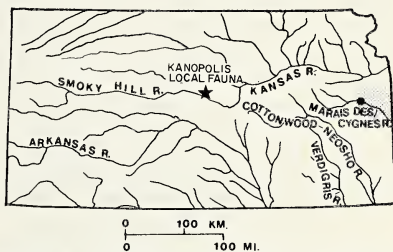


Figure 2. Distribution of *Arcidens confragosus* (dot) in Kansas and location of Kanopolis local fauna (star). (After, Murray and Leonard, 1962.)

Preservation of the unionid material was poor with much of it either badly fragmented or exfoliated. Specimens had to be impregnated with a solution of acetone-soluble resin that hardened upon drying, and excavated as blocks of fossil bearing matrix. The sphaeriids were collected by a screenwashing technique developed by Hibbard (1949). The condition of the unionid material made identification difficult or in some cases impossible, thus the unionids in the fauna probably represent only the minimum number of individuals and taxa.

Data for the Kanopolis pelecypod fauna are summarized in Table 1. The fauna includes four species, *Tritogonia verrucosa*, *Arcidens confragosus*, *Quadrula pustulosa* and *Carunculina parva*, not previously reported as fossil in the state, and extends the stratigraphic range of four other species, *Unio merus tetralasmus*, *Quadrula*

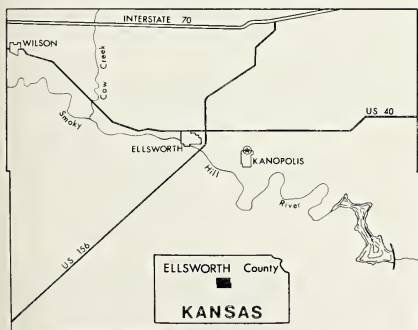


Figure 1. Location of Kanopolis local fauna (star), Ellsworth County, Kansas.

Table 1

KANOPOLIS LOCAL FAUNA PELECYPODS

Species	KSU Catalog Number	Number of Specimens
<i>Tritogonia verrucosa</i> (Rafinesque)	3557	1 (left valve)
<i>Arcidens confragosus</i> (Say)	3560	2 (articulated) + 2 (right valves)
<i>Ligumia subrostrata</i> (Say)	3556	2 (articulated) + 3 (left) + 4 (right valves)
<i>Anodonta grandis</i> (Say)	3552	3 (left valves)
<i>Unio merus tetralasmus</i> (Say)	3558	2 (left valves)
<i>Carunculina parva</i> (Barnes)	3554	7 (left) + 2 (right valves)
<i>Quadrula quadrula</i> (Rafinesque)	3553	7 (left) + 10 (right valves)
cf. <i>Quadrula pustulosa</i> (Lea)	3555	19 (left) + 10 (right valves)
cf. <i>Lampsilis anodontoides</i> (Lea)	3559	1 (articulated) + 4 (left) + 4 right valves)
<i>Pisidium casertanum</i> (Poli)	3561	7 (valves)
<i>Pisidium compressum</i> (Prime)	3562	1 (articulated) + > 200 (valves)
<i>Sphaerium lacustre</i> (Müller)	3563	5 (valves)
<i>Sphaerium transversum</i> (Say)	3564	44 (valves)
<i>Sphaerium striatinum</i> (Lamarck)	3565	10 (articulated) + > 300 (valves)

quadrula, *Anodonta grandis* and *Sphaerium transversum*, back to the Yarmouthian Stage.

All of the unionid species except *Arcidens confragosus* and *Lampsilis anodontoides* can now be found living in the Smoky Hill-Kansas drainage within Ellsworth County (Miller and Hibbard, 1972). The closest extant record of *L. anodontoides* in the Smoky Hill-Kansas system is from Riley County (Scammon, 1906). The only reported Holocene occurrence of *A. confragosus* in Kansas is from the Marais des Cygnes River (Figure 2) (Murray and Leonard, 1962). With the exception of *Sphaerium lacustre*, all of the sphaeriids are known to occur in Ellsworth County (Miller and Hibbard, 1972).

Most of the unionid species are restricted to lotic environments. The lenticular-shaped, medium to coarse sand from which the unionids were collected, together with the diversity of the unionid fauna, suggest that the depositional site was a series of point-bars in a river of at least the size of the modern Smoky Hill River where it now flows through Ellsworth County. The preservation of articulated valves and of delicate beak sculpture in some specimens are considered indicative of slow moving water with little or no

suspended load and a stable, nonshifting substrate.

The Kanopolis local fauna has been considered Yarmouthian in age based on the evolutionary development of some of the vertebrate taxa and the climatic implications of the fauna (Zakrzewski, 1975). The pelecypod fauna, unfortunately, includes no species that are useful in assessing the age of the assemblage.

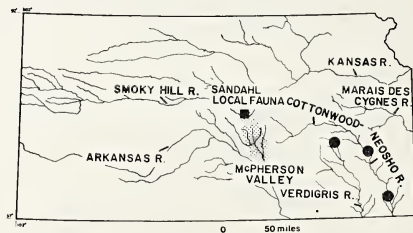


Figure 3. Distribution of *Pleurobema cordatum catillus* (dots) in Kansas. The location of the Sandahl local fauna is indicated by the square, and the McPherson Valley by the small dot pattern. (After, Miller, 1970.)

The presence of *A. confragosus* in the Kanopolis local fauna marks the second disjunct occurrence of a unionid species as a fossil in the upper Smoky Hill drainage. Miller (1970) reported *Pleurobema cordatum catillus* from the Illinoian stage Sandahl local fauna. This species is now restricted in Kansas to the Verdigris and Cottonwood-Neosho systems (Figure 3). Some of the fish taxa from the Kanopolis local fauna also have modern distributions in Kansas which are centered in the Verdigris-Cottonwood-Neosho drainage (Neff, 1975). These distributions invite speculation on the possibility of a former confluence between the upper Smoky Hill, the Cottonwood-Neosho, and perhaps the Marais des Cygnes Rivers sometime during the Yarmouthian and/or Illinoian stages of the Pleistocene.

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PRINTING of the UNPUBLISHED VÉLINS (53 plates) of LAMARCK (1802-1809)
 SUR les FOSSILES des ENVIRONS de PARIS, ... ESPÈCES ...
 ANIMAUX MARINS SANS VERTÈBRES...

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To those persons who traffic in the study and names of the genera of the molluscan world, Recent and fossil forms, the name of Jean Baptiste Lamarck (Jean-Baptiste-Pierre-Antoine de Monet, Chevalier de Lamarck) is one of the familiar names next to Linnaeus. Such common generic names as *Terebra*, *Phasianella*, *Pyramidella*, *Crepidula*, *Cancellaria*, *Nucula*, *Crassatella*, *Modiolus*, *Petricola* are Lamarckian. There would be more if that ill-advised ruling of the International Commission on Zoological Nomenclature had not replaced such old familiar names of Lamarck, 1799, of *Solarium*, *Sigaretus*, *Pyrula*, and *Rostellaria* by *Architectonica*, *Sinum*, *Ficus*, and *Tibia* of Röeding in Bolten, 1798. In 1799 Lamarck published the "*Prodrome d'une nouvelle Classification des Coquilles...*" in which the forementioned names of Lamarck originated. In 1801, "*Système des Animaux sans vertèbre ou tableau général des classes, des orders et des genres de ces animaux*"; in 1802-1809, *Memoires "Sur les fossiles des environs de Paris, comprenant la détermination des espèces qui appartiennent aux animaux marins sans vertèbres, et dont la plupart son figurés dans la collection des vélins du Muséum"*; in 1818-1822, "*Histoire naturelle des animaux sans vertèbres*," of seven volumes, were published. The greater portions of those works were on mollusks and contain basic genera of that group. In the 1802-1809 treatise on the fossil mollusks of the Eocene of the Paris Basin, Lamarck continually brought out the characters of the genera as exhibited by living forms over the seas of the world, and he made new generic names based on Recent shells.

The taxonomic books of Lamarck, except the 1802-1809 series on the mollusks of the Eocene of the Paris Basin, are fairly accessible in special libraries even though they are rare and probably difficult to obtain as personal copies. The 1802-1809 work was published in about 45

separate parts through a seven year period in the *Annals of the Museum national d'Histoire naturelle*. This is a rare series for a general library to have and a tedious chore for a student to search and examine. The title stated that figures of the species for the most part were in the Collection of the Vélins of the Museum. From 1805-1809 Lamarck did publish illustrations with figures, 28 plates, of some of the species; but such figures did not include the complete series of illustration of the references to the "Vélins" (Plates 1-53).

The treatise of 1802-1809 is imperative for students working on the Eocene of the world, as well as the fossil and Recent Mollusks. Researchers are handicapped in using the series because of the inaccessibility of the rare work and because of the mysterious reference to *Vélins*. Because of the uniqueness of the Vélins it is possible to examine those illustrations only in Paris and in the archives of the National Museum.

To understand the situation involved in the association of Lamarck and the Vélins, one must recall a portion of the life of the man. In the years 1772-76 Lamarck studied medicine and botany in the "Jardin du Roy." In the following years he was occupied and published on botanical subjects. In 1788 he had the post of Botanist in the Jardin du Roi until 1793; by decree of the New Convention, the Jardin du Roi became the Museum d'Histoire naturelle. Lamarck was named Professor of Zoology in charge of the study of invertebrate animals. It was during the following years that he continued his elaboration of the classification of the invertebrates in association with the Museum. Prior to Lamarck's time in the 17th century, drawings of plants had been executed and preserved. These were the so-called Vélins, and by 1660 they comprised five large folio volumes. The series was continued and included the works by famous artists. Hence in 1890 Lamarck recognized the importance of the

Vélins and utilized the method to illustrate his great and extensive production of the famous fossils of the Paris Basin. The collection consisted of the fossils of Defrance and of Lamarck from the rich Eocene deposits in the area surrounding Paris.

A review of the background of the periods immediately before, and during, the research and production of Lamarck's life is in order. In 1789 the French Revolution began with the Fall of the Bastille. The Bastille was across the River Seine from the then Jardin royal des Plantes. In 1793 the Jardin royal became the Museum Natural history. Lamarck during those years was from 45-49 years of age. He was the Professor of Zoology, in the Museum, and the events of the Reign of Terror were witnessed at close quarters. In 1799 he wrote the *Prodrome* which established the names of many well-known genera of mollusks. The 1802-1809 was past the initial decree of cancellation of the first name of persons, the decree is apparent in the format of publications. The title page gave the name of Lamarck (no initials), his discussion stated that the collection studied was that of "citoyen Defrance," 1802, and citoyen Defrance is so-called through 1803, in 3 parts; then on he is designated M. Defrance. Lamarck in 1802 is "Lamarck" and also in parts through 1804; from then on through 1809, he is "M. Lamarck."

Lamarck's descriptions in the *Memoirs* of the species and genera are explicit. They are of simple French, include pertinent characters, give general descriptions and differentiation of genera from older named groups and measurements of the specimens.

Regardless of Lamarck's philosophy of evolution, he stands out as the excellent

systematist of Mollusca. In many aspects of the science he was ahead of his time. No present-day student of the group can count his molluscan studies as complete without access to Lamarck's fossil work of the Paris Basin Eocene.

Funds for the publication of the Lamarck Vélins were made possible by the generous help of Robert and Shirley Hoerle of West Palm Beach, Florida. I am compiling the explanations of the Vélins and the reprint of the text. A history and description of the Vélins by M. Laissus, conservateur of the Bibliotheque centrale du Museum national d'Histoire naturelle, and a biographical sketch of Lamarck by Denise Mongin, paleontologist in Paris, will be included as introductions with the plates. A photograph of the statue of Lamarck which is in the Jardin des Plantes will be the frontispiece.

Over years of work on the Eocene and the mollusks, one has been puzzled, worried, and frustrated as to the so-called references to the "Vélins." In 1956, a set of copies of Vélins of Lamarck was advertised in an European Second Hand Catalogue. It was purchased. In 1974 a second set (copies) was obtained. Many of the copies of the Vélins bear the mark of the Museum national d'Histoire naturelle. Also, by checking the text of Lamarck with the indication given with the figures and Vélins copies, the authenticity of the illustrations is verified. Because the original plates (Vélins) are in the Museum in Paris, the copies of the photographed set must be used for the publication. After about 174 years a complete folio of the illustrations of Lamarck, 1802-1809 work, will be available. A reprint of the complete text is also in preparation. The 45 separate parts will be combined to make one book. The publication of text and plates will be advertised so that students will become aware of the availability of the books.

CHANGES IN THE DISTRIBUTION OF *IO FLUVIALIS* (SAY, 1825) IN THE UPPER TENNESSEE RIVER SYSTEM (MOLLUSCA, GASTROPODA, PLEUROCERIDAE)

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In 1825 Thomas Say described a new species of river snail from the headwaters of the North Fork of the Holston River at Saltville, Virginia. Because the form of this species at this site resembled marine shells of the Genus *Fusus*, Say called it *Fusus fluvialis*, the "*Fusus* of the rivers." Professor Lardner Vanuxem, a geologist-paleontologist, had collected the type material. He sent specimens to his friend Isaac Lea as well as to Say. Lea (1831: 122), in the belief "that no genus should contain pelagian and fluviatile shells in common," established the Genus *Io* to receive Vanuxem's Holston River shells, which he redescribed as *Io fusiformis*. Thus the Spiny River Snail of the southern Appalachians has come to be known, under the rules of zoological nomenclature, as *Io fluvialis* (Say, 1825).

Additional collections in the upper Tennessee River system over the years brought to light additional forms of *Io* which were given additional names. As the variability of this group of river snails became known to malacologists, interest in it grew. This interest reached its peak in the monographic study of the genus made over its entire known range by Dr. Charles C. Adams. Although Adams' collections were made in 1899, 1900, and 1901, his classic study was not published until 1915.

With perception uncommon in that early period, Adams (1915: 8) wrote: "When we consider the rapid rate at which our native plants and animals are being destroyed by the encroachment of civilization, it will be realized that in a few generations a fairly full account of many of our species will be forever lost. I hope that the present record will be a contribution to the preservation of such 'vanishing data,' and that the photographic record and the collection [now preserved at the Smithsonian National Museum of Natural History] will preserve a reliable sample of one of nature's vast experiments."

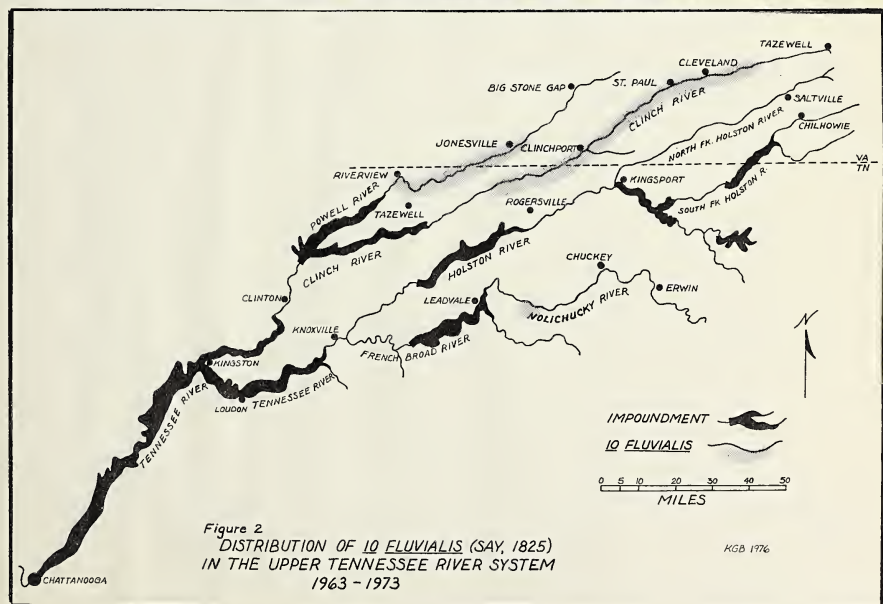
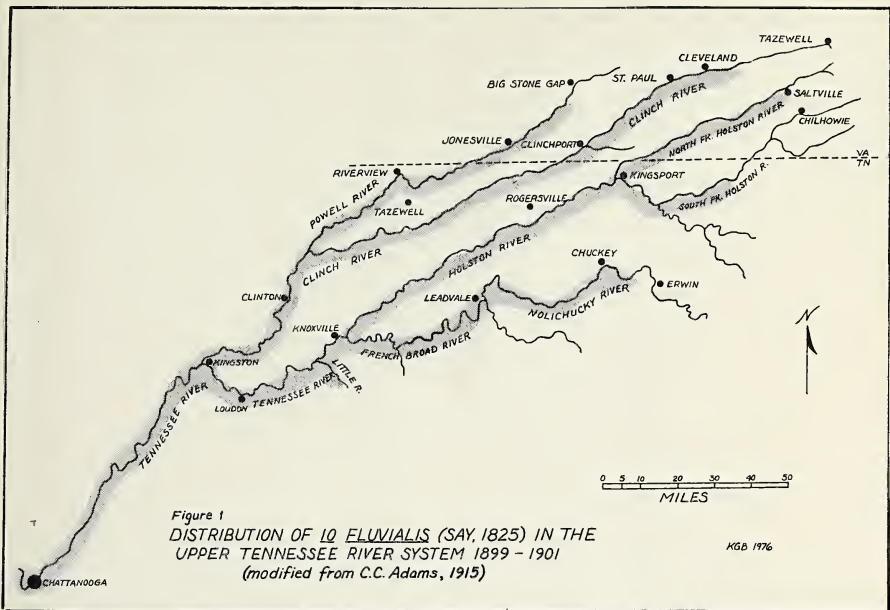
Adams confirmed the fact that the *Io* specimens found in the upper reaches of the

Powell, Clinch, and North Fork Holston Rivers were smooth forms which lacked spines. Moving downstream in these rivers, he found phases of *Io* best described as smooth, undulate, nodulous, low-spined, and finally prominently-spined. Specimens from the uppermost populations in the South Fork Holston River, however, were mainly undulate, while those of the Nolichucky were spinose. In general, the farther downstream an *Io* was taken, the more prominent its spines were likely to be. An exception to this generalization occurred in the main stem of the Holston River near Rogersville, where large numbers of the smooth shells, typical of the headwaters form, were found, together with spinose shells and many intergrading forms.

As can easily be seen from Adams' excellent series of plates, a great deal of variation was found in the *Io* populations of each locality, and the smooth forms appear to intergrade completely with the most spinose forms, indicating that these animals all represent a single, highly polymorphic species.

DISTRIBUTION

No valid records of living or fossil *Io* are known outside the Tennessee River System. It reached its greatest abundance, at least in historic times, in the middle and upper reaches of the Tennessee system upstream from Chattanooga. The downstream limit of its distribution evidently was Muscle (Mussel) Shoals, Alabama, where Hinkley (1906: 40) found a single living specimen of the spinose *turrita* form in 1904. The upstream limits of *Io*'s distribution were reached in tributaries the size of the North Fork Holston River at Saltville, Virginia, the type locality. Goodrich (1913) extended its known range in the Clinch River upstream to Cedar Bluff. A single specimen of the *Turrita* form was reported from Little River about eight miles above its mouth by Clench in 1928. Adams searched the Hiwassee and Sequatchie Rivers and South Chickamauga Creek without finding any specimens of this complex.



The known original range of *Io*, except for the lone Muscle (Mussel) Shoals record and another live specimen taken in the main stem of the Tennessee River a few miles above Bridgeport, Alabama, by Adams, is shown in Figure 1.

The present distribution of *Io fluviatilis* is shown in Figure 2, which is based upon specimens collected within the past two decades now deposited in the Ohio State University Museum of Zoology collection. These specimens, their condition, year of collection, and locality are listed in the accompanying table. *Io* appears to have been extirpated from the main stem of the Tennessee River, the entire Holston River system, and the French Broad River. We have found it living at one site in the Nolichucky River, where it is now very rare. In the Powell River we have found living specimens from near Pennington Gap, Lee County, Virginia, downstream as far as Riverview, Claiborne County, Tennessee. The Clinch River from Blackford, Russell County, Virginia, downstream to Sneedville, Hancock County, Tennessee, harbors most of the world's remaining populations of living *Io*.

HABITAT REQUIREMENTS

Our early collections of *Io* led us to believe that it was a creature of rushing waters, and that the collector should be prepared to collect with one hand while hanging on to a firmly seated boulder or a bedrock ledge "for dear life" with the other. *Io* populations are definitely associated with the rapid waters of riffles or shoals, but we soon learned that they are also found in the smoother stretches of runs below these rapids. An *Io* swept into a deep, quiet pool, however, appears to be an *Io* doomed to an early death. We have found only dead shells of this species in such pools. It may be, however, that these shells were washed into the pools after the animals had died.

Ms. Annie Law, a collector of the 1800's, observed: "The muscular power of *Io* is astonishing. I frequently find one adhering to a rock half as large as my head, and when I take up the shell, it brings the rock with it and requires much force to separate it" (Lewis, 1871: 233).

HABITAT CHANGES

Nearly all of the shoals of the Tennessee River and the lower reaches of its major tributaries are now buried beneath many feet of slack water in impoundments behind high dams. We know of no recent records of living *Io* from these impound-

ments. *Io* also appears to be absent from the rapid tailwaters of these dams, perhaps because of the great short-term variations in stream flow associated with power generation during peak and low demand periods.

In addition to *Io*'s eradication from its former downstream range, it is now losing headwater habitat because of pollution. Athearn (1968: 44) reported, "The June 1967 pollution of the Clinch River in Virginia by the Appalachian Power Company killed hundreds of thousands (of mollusks.) Among the many mollusks and other plants and animals killed was the best remaining concentrated population of our AMU symbolic mollusk *Io fluviatilis*."

Several communities, such as Tazewell, Virginia, along the *Io* streams of the upper Tennessee have recently installed municipal sewage treatment facilities, replacing former septic tank systems. Below the outfalls of these sewage treatment plants the rich endemic molluscan fauna of these streams is rapidly disappearing. The killing effect appears to be spreading downstream from these towns and is affecting not only the pleurocerids, but also the naiades. Communities which still have the septic tank treatment systems, such as Fort Blackmore, Dungannon, and Clinchport, do not appear to have an adverse effect on the molluscan fauna of the rivers.

Below Big Stone Gap in the upper Powell River, *Io* and other aquatic mollusks are absent for some miles downstream. The suspected cause is acid mine drainage from the North Fork above Big Stone Gap. The South Fork of the Powell at and above Big Stone Gap still retains a rich pleurocerid fauna, though *Io* evidently never occurred this far upstream. If coal mining is expanded further into the Clinch River watershed, acid mine drainage could eliminate the richest remaining populations of *Io*.

In the North Fork of the Holston River the *Io* population has suffered from the outfall of the chemical industry at Saltville since before 1900 (Adams, 1915: 18). No living populations of *Io* are now known to exist anywhere in the Holston River system (Stansbery, 1972; Stansbery and Clench, 1974). Since the Saltville chemical plant has now ceased operations, it is possible that the Holston River will eventually recover its ability to support a diversity of molluscan life. If so, then perhaps it will be possible to successfully reintroduce *Io* into the Holston from seed populations in the Powell,

Clinch, or Nolichucky---if these are still surviving.

Efforts are being made to preserve the natural integrity of what is left of *Io*'s habitat. If the remaining high-quality stretches of the upper Clinch, Powell, and Nolichucky can be protected from further degradation, this unique American river snail and the many other endemic species associated with it in the upper Tennessee drainage may be preserved for future generations.

ACKNOWLEDGEMENTS

We would like to express our appreciation to the following people, who have contributed specimens of *Io* to the OSUM collection or who have helped us make the field collections of specimens upon which this paper is based:

Herbert D. Athearn, Constance Boone, Kathy G. Borrer, David Carter, William J. Clench, Jon E. Ditmars, John Frederick, Jr., Carolyn Cooper Jenkinson, John J. Jenkinson, Edna Kirby, Harvey Meyer, Frank J. Moore, Joanne Stillwell Kirkpatrick, William Stillwell, Donald P. Tanner, and Richard A. Tubbs.

IO FLUVIALIS SPECIMENS COLLECTED SINCE 1950, DEPOSITED IN THE OHIO STATE UNIVERSITY MUSEUM OF ZOOLOGY

(Records arranged in upstream to downstream sequence for each river listed.)

POWELL RIVER

Virginia, Lee County

OSUM-7260	Live	1967	2.3 mi. SE of Pennington Gap
OSUM-7264	Live	1967	7.7 mi. SW of Pennington Gap

Tennessee, Claiborne County

OSUM-7267	Live	1967	At Hoop, 9 mi. NE of Tazewell
OSUM-7270	Live	1967	At Hoop, 9 mi. NE of Tazewell
OSUM-7274	Live	1968	At Hoop, 9 mi. NE of Tazewell
OSUM-7276	Live	1969	At Hoop, 9 mi. NE of Tazewell
OSUM-7277	Live	1973	At Hoop, 9 mi. NE of Tazewell
OSUM-7278	Live	1967	At Riverview, 10.5 mi. W of Hoop

CLINCH RIVER

Virginia, Russel County

OSUM-4535	fresh	1965	At Blackford, 2.5 mi. SE of Honaker
OSUM-7279	subfossil	1973	At Blackford, 2.5 mi. SE of Honaker
OSUM-7285	subfossil	1965	At Cleveland, 10.8 mi. WSW of Honaker
OSUM-7286	live	1973	At Cleveland, 10.8 mi. WSW of Honaker
OSUM-7297	subfossil	1963	At Boody (Fink), 1 mi. E of St. Paul
OSUM-7299	fresh	1963	At St. Paul, 9 mi. WSW of Cleveland
OSUM-7298	dead	1965	At St. Paul, 9 mi. WSW of Cleveland
OSUM-7291	subfossil	1973	At St. Paul, 9 mi. WSW of Cleveland

Virginia, Scott County

OSUM-7300	live	1965	At Dungannon, 7.3 mi. NE of Fort Blackmore
OSUM-7301	live	1963	At Fort Blackmore, 10.7 mi. NE of Clinchport
OSUM-7302	live	1965	At Fort Blackmore, 10.7 mi. NE of Clinchport
OSUM-7306	live	1963	At Clinchport, 2.2 mi. N of Speers Ferry
OSUM-7303	fresh	1970	At Clinchport, 2.2 mi. N of Speers Ferry
OSUM-7308	live	1973	At Clinchport, 2.2 mi. N of Speers Ferry
OSUM-7311	live	1965	Above the mouth of Copper Creek, 1.3 mi. S of Clinchport

OSUM-7315	live	1966	At the mouth of Copper Creek
OSUM-7317	live	1973	At the mouth of Copper Creek
OSUM-7312	live	1970	Copper Creek immediately above its mouth
OSUM-7316	live	1963	At Speers Ferry, 2 mi. S of Clinchport
OSUM-7320	live	1963	1-2 mi. below Speers Ferry
OSUM-7322	live	1963	1-2 mi. below Speers Ferry
OSUM-7321	live	1965	1-2 mi. below Speers Ferry
OSUM-7323	live	1974	6.2 mi. SW of Clinchport, 12.2 mi. NE of Kyles Ford

Tennessee, Hancock County

OSUM-4528	fresh	1972	13.8 mi. SW of Clinchport, 4.5 mi. E of Kyles Ford
OSUM-7330	live	1968	Below The Rounds, 3.5 mi. E of Kyles Ford
OSUM-7324	live	1972	Below The Rounds, 3.5 mi. E of Kyles Ford
OSUM-7327	live	1974	Below The Rounds, 3.5 mi. E of Kyles Ford
OSUM-7331	fresh	1970	2 mi. above Kyles Ford, 11.2 mi. E of Sneedville
OSUM-7334	fresh	ca. 1958	At Kyles Ford, 10.2 mi. ENE of Sneedville
OSUM-7335	live	1965	"
OSUM-7338	live	1967	"
OSUM-7339	subfossil	1968	"
OSUM-7342	live	1969	"
OSUM-7343	fresh	1971	"
OSUM-7346	live	1973	"
OSUM-7349	subfossil	1967	"
OSUM-7351	live	1967	From Brooks Island to Alder Hollow, 5 mi. E of Sneedville
OSUM-7363	live	1968	"
OSUM-7354	live	1969	"
OSUM-7358	live	1974	"
OSUM-7366	fresh	1967	Below Garland Hollow, 1.1 mi. SE of Sneedville
OSUM-7367	live	1972	"
OSUM-7370	live	1974	"

Tennessee, Claiborne/Grainger Counties

OSUM-7376	subfossil	1968	Below U.S. Rt. 25E bridge, 7.2 mi. SE of Tazewell
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NOLICHUCKY RIVER**Tennessee, Greene County**

OSUM-7255	subfossil	1968	2.5 mi. S of Chuckey (Indian midden shells)
OSUM-7259	live	1964	Hale Bridge, 3.3 mi. SE of Warrensburg
OSUM-7258	live	1968	"

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THE ROLE OF THE "HOME SCAR" IN PULMONATE LIMPETS

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Pulmonate limpets in the genus *Siphonaria* consistently return to locations on intertidal rock surfaces termed "home sites" (Cook 1969, 1971). Although the exact timing and extent of grazing movements away from home sites can vary with the phase of the monthly tidal cycle and the particular population studied (Cook in preparation), homing individuals invariably occupy home sites at dead low tide and at maximum flood tide. When limpets are away from home sites, the areas can be recognized by a characteristic bluish or greenish tint. On relatively soft rocks, the home site is also marked by a slight depression or "home scar". When limpets are at home on such rocks, the outline of each animal's shell fits snugly against the edge of the scar.

Several "raisons d'être" have been proposed for the tightly fitting scars of homing limpets, both pulmonates such as *Siphonaria* and prosobranchs such as *Acmaea scabra*. These include protection from desiccation during low tide when the limpets are out of water and exposed to the direct rays of the sun, protection from wave action at high tide, protection from predators both at high and low tides and protection of soft parts against damage from sediment swept across rock surfaces at high tide. Wolcott's work (1973) suggests that scars are significant in preventing desiccation during aerial exposure at low tide in the prosobranch *Acmaea scabra*; there is no information on the function of scars in pulmonate limpets.

Records of the movements of individual limpets within populations should provide data on when and how animals are lost from limpet populations. In turn this information should provide insight into the possible ways in which scars benefit limpets. For example, intensive observation may show that limpets are successfully attacked by predators when they are off their scars and are relatively safe from predation when "at home"; this would indicate that scars may serve as "refugia" against predation. In this

paper I describe preliminary observations on the role of home scars in two species of *Siphonaria*.

Work on *Siphonaria normalis* Gould was carried out at the Mid-Pacific Marine Laboratory, Enewetak Island, Enewetak Atoll, Marshall Islands (formerly known as the Eniwetok Marine Laboratory, Eniwetok Island, Eniwetok Atoll). Work on *Siphonaria alternata* Say was done at the Bermuda Biological Station for Research, St. George's West, Bermuda. At both locations quadrats of various sizes were outlined on intertidal rocks with paint. Most records of the movements of individual animals within the quadrats were made by noting successive positions of individuals on a map of the quadrat drawn to scale. To construct this record, distances of individuals from home scars were periodically measured with a ruler to the nearest half centimeter, while headings were visually estimated relative to home scars and the outlines of the quadrat. Occasionally movements were recorded on film with a 35 mm time-lapse camera. At Enewetak individual animals could be identified by distinctive shell shape and markings; in Bermuda limpets were marked by attaching a numbered label to each animal's dry shell at dead low tide with Eastman 910 cement.

Siphonaria normalis in Enewetak move in response to tidal cycles in a manner similar to that of *Siphonaria normalis* in Hawaii (Cook 1969). The animals begin to move as the water level falls past their scars on ebbing tides and move again as the flood tide begins to dampen their scars. Each movement period includes an outbound grazing trip away from the scar and a return leg back to the scar. Animals return home well before dead low tide and well before the height of the flood tide. *Siphonaria alternata* in Bermuda have the same response to flooding tides as do *S. normalis*; however, Bermuda limpets occasionally anticipate the ebbing tide and begin to move when their scars are still covered by 10 - 15 cm. of water (Cook in preparation). Otherwise, their response

to ebb tides is similar to that of *S. normalis*. Observations of both species began about an hour before the expected onset of movement and continued until all animals had returned home. With the exception of certain individuals which occasionally failed to home (see below), animals were never seen to move except at the anticipated time. Mortality was estimated by the loss of individuals between observation periods; since limpets do not move more than 20 cm on any given trip (Cook in preparation), any limpet which was not found within 20 cm of the perimeter of the quadrat was considered missing.

Two sites (4-1 and 5-1) were examined closely at Enewetak. Site 4-1 (25 cm x 25 cm, containing 19 limpets) was located on a gently sloping intertidal bench on the lagoon side of Enewetak Island (Site Fred) about .5 m above Mean Lower Low water. Site 5-1 (15 cm x 15 cm, containing 22 limpets) was located 1.0 m above MLLW in a more steeply sloping area at the base of a seawall several hundred meters southwest of site 4-1. Limpets in quadrats 4-1 and 5-1 were observed on different days.

In Bermuda all quadrats were located on limestone benches adjacent to the Bermuda Biological Station's boat dock on Ferry Reach. Quadrat A (25 cm x 25 cm, containing 10 limpets) and quadrat B (25 cm x 25 cm, containing 20 limpets) were located on the same bench about 1.0 m above MLLW; the sites were separated by no more than 50 cm. Although both sites were at the same level in the intertidal, site A typically drained faster following an ebbing tide; this resulted in greater aerial exposure for the animals there. Two observers recorded movements within each site simultaneously so that the data from the two sites represent identical time periods and general conditions. A third site, D, was located lower in the intertidal than sites A and B; this site was used for replacement experiments described later in this paper.

Enewetak observations. Every animal in the Enewetak populations consistently returned to its home scar following outbound trips. While quadrats were observed, there was no predation on limpets and no evidence that animals were ever swept off rocks by wave action. At site 4-1 between 1300 hours and 2100 hours on October 6, 1975, four limpets were missing following a spring flood tide (+1.5 m). When the scars of these individuals were examined closely on

October 7, distinctive double lines were seen to extend into empty scars from the surrounding rock. These marks resembled the grooves characteristically made by parrotfish (Scaridae) as they browse on algae-covered rock surfaces (Randall 1974; Cook in preparation). In the area around site 4-1 empty scars which had been marked in this way were common on October 7; in several places, the remnants of *Siphonaria* still clung to marked scars. Clearly, scars do not effectively protect limpets from browsing reef fish.

Muricid gastropods have been reported to feed on *Siphonaria* at Enewetak (Menge 1973, Miller, A., unpublished report to the Enewetak Marine Laboratory); *Thais armigera* attacks *Siphonaria* by prying limpets off rocks with its foot (Menge 1973). However, neither report indicates if predation success is higher when limpets are at home or away from scars. Golden plovers [*Pluvialis dominica*] commonly forage over Enewetak seaward bench platforms in places where *Siphonaria* is very abundant and are probably consuming limpets (A. Kohn personal communication), although there is no direct evidence of this. It would be most interesting to know if these birds are feeding during periods when limpets would be moving or when they are in scars.

Bermuda observations. In Bermuda I found no evidence of predation on *S. alternata* during the more than 500 homing cycles observed; I also found no evidence that limpets were removed from rocks by wave action. My observations in Bermuda did suggest that home scars may be important to animals which face longer exposure to air on ebb tides. Twice during my observations a limpet from quadrat A failed to return home following a grazing expedition. Neither animal returned to its scar on subsequent tides; instead, both remained at the end of their outbound paths for several tidal cycles and then vanished from the area. Just before these limpets disappeared, their partially exposed feet were surrounded by swarms of ants at low tide.

The limpets in quadrat B were less exposed to drying conditions at low tide. During my observations, more than half of the animals at B failed to home at one time or another. Most of these animals either returned to their original scars on subsequent tides or had formed new scars elsewhere on the rock by the end of the

TABLE 1. INCIDENCE OF FAILURE TO HOME. ITS CONSEQUENCES FOR LIMPETS.

Data from simultaneous observation of two sites in Bermuda over 19 tides.

SITE	# OF LIMPETS	# OF HOMING TRIPS	# OF FAILURES	FATE OF NON-HOMING LIMPETS		
				Lost from Site	Formed new scars	Eventual return to old scar
A	10	185	2	2 (100%)	0	0
B	20	256	11	2 (18%)	6 (55%)	3 (27%)

study (Table 1). Two of these non-homing limpets (18% of those which had failed to home) eventually disappeared; neither of the "non-homers" at site A survived, in contrast.

The relative importance of scars in low versus high intertidal areas was examined by a preliminary series of replacement experiments using the Bermuda populations. In these studies limpets were marked with paint and returned to the intertidal in two areas. Most of the animals were placed on unoccupied rock between the scars of limpets normally resident at A; no extra scars were available for occupancy. Four replacement experiments were performed at site A. Other limpets were placed on site D; as mentioned before this site was lower in the intertidal than A and B and was exposed to air for a shorter period of time on each low tide. No unoccupied scars were evident. In this experiment only one group of limpets was added to the site.

Each day after replacement the number of marked animals which were firmly attached to the rock was determined in both areas; animals which did not attach were considered non-survivors. The percentage of limpets surviving on each day was calculated for each replacement experiment. The loss of animals from site A was initially quite rapid; within three days the population appeared to reach a stable value of 36% of the original number (Figure 1). Survival at the less exposed site appeared to be greater; however, this experiment was not continued beyond four days.

During the first two days after replacement at site A, numerous limpets were found in a generally moribund condition. These animals responded only slightly to mechanical stimulation

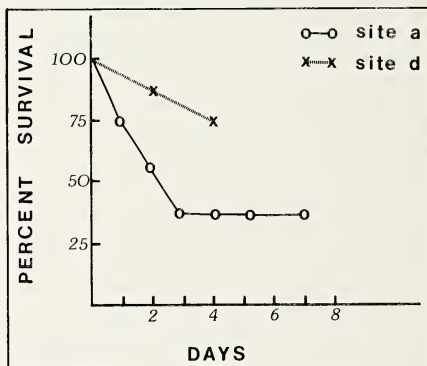


FIGURE 1. Survival of limpets after replacement at two sites in Bermuda. Site A is higher in the intertidal than D. % survival values for days 1 and 2 at site A are means of data from four separate replacement experiments; values for days 3 - 7 are means of two experiments. Values for site D represent one experiment only.

and would not firmly attach to rocks; because they could not attach, they were not counted as "survivors" in replacement data. Pedal tissue appeared to be much less pliant than usual and mantle edges had withdrawn from the edges of the shell margin. The animals which had been placed at the lower site were never found in this condition. One interpretation of this is that tissues of animals without home scars in the higher intertidal are more subject to desiccation

than are tissues of scar-less individuals in less exposed areas; the presence of a home scar is more crucial for limpets higher in the intertidal. In this view the observed ant-limpet interactions occur when ants are attracted to a desiccated and dying limpet. An alternate explanation of my observations is that limpets without scars in the high intertidal may be more subject to predation by ants at low tide than those further down; "ant attack" may be the prelude to a moribund condition followed by desiccation.

Although this preliminary work suggests that limpets may be more likely to consistently return to scars without periodic homing failures in areas which are more exposed on ebb tides, additional data on the consistency of homing in relation to tide level and survival after replacement are required. It may also be feasible to measure water loss from individuals on scars and individuals off scars in replacement experiments during periods of drying to determine if the scar is effective in reducing water loss; other mechanisms which may be used to reduce desiccation, such as the production of mucous sheets between shell margins and rock surfaces seen in *Acmaea digitalis* (Wolcott 1973) should be examined. An additional physiological function of the scar may be to reduce osmotic stress when animals are exposed to fresh water; I have observed that limpets return to scars immediately after rain showers begin. The osmotic consequences of being off or on scars at such times should be investigated.

In summary, it appears that the home scars of intertidal pulmonate limpets in the genus *Siphonaria* do not protect the animals from predators such as parrotfish. It is more likely that the scars afford limpets protection from stresses encoun-

tered during periods of aerial exposure during low tides. These stresses include desiccation, predation by foraging ants and possibly osmotic stress from freshwater runoff.

My research has been supported by funds from the Energy Research Development Administration, a National Science Foundation grant to the Bermuda Biological Station, and the Irma E. Voigt fellowship from the American Association of University Women. This paper is a contribution of the Mid-Pacific Marine Laboratory and is Contribution #676 from the Bermuda Biological Station for Research, Inc.

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SPIRAL CORD VARIATION OF *ODOSTOMIA IMPRESSA* (SAY) AND
O. SEMINUDA (C. B. ADAMS) FAMILY PYRAMIDELLIDAE

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A frequently used taxonomic characteristic of the pyramidellids *Odostomia impressa* (Say, 1822¹) and *O. seminuda* (C.B. Adams, 1839) has been the number of spiral cords per whorl. Variation in these counts has heretofore not been well documented. The following study is an attempt at describing some of this variability.

Specimens used are all from North Carolina waters and, except for a fossil *seminuda* collection², are from the mollusk collection of the UNC Institute of Marine Sciences. Samples, where possible, represent a wide range of localities and times of collection.

The *impressa* data includes material from nine samples, all living epifauna of the common Eastern Oyster, *Crassostrea virginica* (Gmelin). Samples were from Shallotte River in southern North Carolina estuarine waters to near the mouth of Neuse River and Back Sound in central North Carolina waters. Months sampled include January, March, May and September through December.

The *seminuda* specimens used in the study were taken from the following three distinct populations: B, C, and D.

B population includes specimens from seven epifaunal, *Argopecten irradians* (Lamarck) samples collected from the two major North Carolina Bay Scallop producing areas, Bogue Sound and Whitehurst Island - the latter near Cape Lookout. Collections were made during April, August, October, and December.

C population includes specimens from 14 samples. Samples were extracted from stomach contents of collected seastars, *Astropecten articulatus* (Say), caught on existing North Carolina offshore beds of the Calico Scallop, *Argopecten gibbus* (Linne) - for location see Porter and Wolfe, 1972. While no collections were made from the scallop epifauna, unpublished data by the author supports the belief that these *seminuda* were part of it epifauna (note also Wells, Wells, & Gray, 1964).

The D population represents one single sample and was collected from a Pliocene-age bed of fossil *Crepidula fornicata* (Linne) occurring at Johnson Point on the Neuse River; this bed is reported by Mr. Eric N. Powell (personal communication) to be made up almost exclusively of *C. fornicata* and *O. seminuda*.

Measurements and counts were made under magnification. All *seminuda* samples were presoaked in chlorox to improve clarity of spiral cords; this was found not necessary for *impressa* samples. Spiral cords were counted only at the juncture of the penultimate and body whorls. Sample data was lumped to facilitate statistical understanding and simplicity.

Odostomia impressa (Say)

Say (1822) describes *Turritella impressa* as having "4 acute, impressed revolving lines". Abbott's (1968) description notes 3-4 spiral ribs on the upper whorls and in 1974 notes 4 spiral cords but uses an illustration with 5 cords. Photographs of *Menestho impressa* (Ode & Spears, 1972) have 3.5 and 5 spiral cords; Emerson and Jacobson (1976), like Say, note 4 spiral grooves.

North Carolina *impressa* are here shown to have 3-6 spiral cords per whorl with 94% between 4 and 5 (see A, Fig. 1). About 5% contain less than 4 spiral cords, these specimens resemble *O. trifida* (Totten, 1834). Ode and Spears (1972), noting reduced spiral cord counts in *impressa*, suggest that *trifida* and *impressa* may be the same. Abbott (1968) mentions that *trifida* may be a form of *O. bisuturalis* (Say, 1822); his illustration of *trifida* has very weak basal spiral cords on the body whorl, a condition not apparent in my specimens with 3 spiral cords. North Carolina *impressa* specimens were collected live from *Crassostrea virginica*; Emerson and Jacobson (1976) list *trifida* as parasitic on *Mya arenaria* Linne. Dr. Robert Robertson (personal communication) has advised that the relationship between *impressa*, *trifida*, and *bisuturalis* at

present is of an unresolved complexity.

A direct relationship exists between number of spiral cords and shell length of *impressa* (see A, Fig. 1). Mean shell length of specimens having a specific spiral cord count is significantly greater than the mean length of those specimens of the preceding spiral cord number in all cases except for 5.5 and 6 — this latter group having insufficient numbers for statistical graphing.

1 The date "1821" is used by most recent authors. Say's paper was read in 1821 but not published until 1822, so the former is incorrect.

2 Property of Dr. Walter Wheeler, Geology Department, University of North Carolina at Chapel Hill.

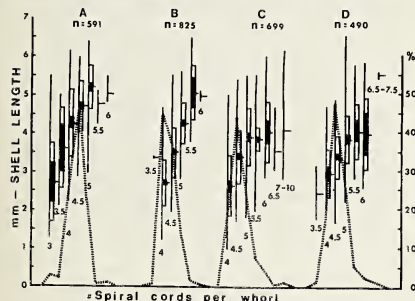


Fig. 1. Relation of number of spiral cords at end of the penultimate whorl to total shell length in *Odostomia impressa* and *O. seminuda*. A = *O. impressa* population; B-D = *O. seminuda* populations, B = population from Bay Scallop, C = population from Calico Scallop beds, D = population from Pliocene *Crepidula fornicata* deposit. N = number of specimens in each population sampled. Dotted line represents percent population having a certain spiral cord count. Block diagrams are adapted from Hubbs & Hubbs (1953): Vertical lines = range of data; horizontal line = mean length of population; hollow blocks = range of $\pm$ one standard deviation about the mean; solid blocks = range of two standard errors about the mean. It is stated that considerable reliance can be placed on the significance between samples, populations in this case, if the solid blocks are slightly separated or do not overlap by more than 33% of the smaller solid block.

Odostomia seminuda (C. B. Adams)

The original description of *Jaminia seminuda* (see Clench & Turner, 1950) contains no mention

of the number of spiral cords per whorl but the picture of the original figure has 4 cords; Clench & Turner's photograph of the lectotype has 5.5 cords. Wells & Wells (1961) describe *seminuda* as having 4 rows of tubercles on each whorl. Abbott (1968) uses an illustration with 5 cords; in 1974 he states that the upper whorls have 4 strong spiral cords but that the last whorl has 5 or 6 cords. Ode & Spears (1972) state that the species is quite variable and depict the species with a photograph having 5 spiral cords.

Two observed processes in *seminuda* are believed to account for spiral cord counts greater than 4, these processes were found in all three populations. Frequently the posterior portion of the outer lip of the aperture does not cover as many of the basal spiral cords of the body whorl during growth as it covered earlier. Basal spiral cords added by this method to the penultimate whorl can be recognized by the numerous fine axial threads crossing the groove immediately to their posterior (see A, Fig. 2). These fine axial

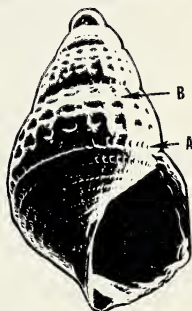


Fig. 2. *Odostomia seminuda* (C.B. Adams) - length of specimen = 1.8 mm. "A" indicates axial threads characteristically found in grooves separating basal spiral cords on the body whorl from each other and from cords on the penultimate whorl. "B" suggests a cord on the penultimate whorl which may be about to split into two cords. Photograph by a Jeol scanning electron microscope.

threads are not characteristically found between the usual spiral cords occurring on the penultimate or earlier whorls but are specifically found in the grooves between the basal spiral cords of the body whorl.

A second process involves the splitting into two cords by any of the stock spiral cords found on the penultimate whorl (note B, Fig. 2). This process seems more prevalent in population C than in B.

Population B (Bay Scallop population)

Specimens have 3.5-6 spiral cords with the largest percentage having 4 cords (4-4.5 cords = 83% population, 4-5 cords = 98%). Characteristic of the *impressa* population, the mean shell length of each succeeding spiral cord group of this *seminuda* population was significantly larger than its preceding spiral cord group (see B, Fig. 1).

Population C (Calico Scallop population)

Specimens in this population have 4-10 spiral cords with most having 4.5 cords (4-4.5 cords = 63% population, 4-5 cords = 87%); note that about 13% of the cord counts are above 5. Mean shell length increases significantly as spiral cord counts increase from 4 to 4.5 to 5; however, mean lengths of shells having 5.5 and 6 spiral cords are not significantly different from the mean length of shells having 5 spiral cords (see C, Fig. 1).

Population D (North Carolina Pliocene *Crepidula* bed)

Specimens have 3.5-7.5 spiral cords with the largest percent 4.5 (4-4.5 cords = 64% population; 4-5 cords = 91%; 8% with more than 5 spiral cords). The relationship of numbers of spiral cords to shell length reflects the pattern exhibited in population C.

The following differences are apparent between the three populations:

1. Population B was parasitic on *Argopecten irradians* while C presumably was on *A. gibbus* and the Pliocene D population on *Crepidula fornicata*.
2. Population B was from estuarine waters while C and probably D were from marine waters.
3. Population B had 98% of its population with 4-5 spiral cords and most with 4 cords; whereas, in population C, only 87% had 4-5 spiral cords and 13% had cord counts above 5. Furthermore, most of the latter population had a cord count of 4.5. Population D was closer to C than to B as it also had a significant percent with cord counts above 5 and

most of the population had 4.5 spiral cords.

4. Mean shell length of population B shells increased significantly as spiral cord counts increased throughout its range; however, in populations C and D no significant increase in mean shell length was noted once a group had 5 or more spiral cords.
5. Mean shell sizes of specimens having 4 spiral cords was similar in both B and C populations; however, the fossil population D was significantly larger. There was no significant difference between the mean lengths of specimens of 4.5 spiral cords in any of the three populations. Mean length of specimens from B population and having spiral cord counts 5-6 are significantly larger than those in either population C or D. In the latter populations, no significant mean length differences were present between groups having 5 or 6 spiral cords.

CONCLUSIONS

Spiral cord counts per whorl in the genus *Odostomia* (Family Pyramidellidae) are variable and within limits the number of cords is directly related to total shell length. In the two *Odostomia* species examined, cord counts for most shells were 4 to 5.5 per whorl; however, counts of *impressa* ranged 3-6 and counts of *seminuda* ranged 3.5-10. In the latter species, the relationship of spiral cord count to total shell length and percent population in the *Argopecten gibbus* bed population seems similar to that in a sampled Pliocene population, probably also an offshore population. Thus, it is of interest that the spiral cord patterns in the estuarine *seminuda* population appear to differ from those of its offshore populations. Further examination of this difference may be warranted.

ACKNOWLEDGMENTS

Population C samples were largely collected as the result of Grant No. 456 of the North Carolina Board of Science and Technology. Existence of the population D fossil sample was made known and furnished to the author by Eric Powell, graduate student. The scanning electron photograph

was taken by Dr. Robert Goll of the Duke University Marine Laboratory. Credit is also extended to Doris Oakely and Tom Whitford for technical aid and to Dr. A. F. Chestnut for manuscript review.

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ABSTRACTS OF PAPERS PRESENTED AT 1976 MEETING

DR. VICTOR STERKI AND SOME OF HIS MALACOLOGICAL CORRESPONDENCE

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Abstract

Dr. Victor Sterki (1846-1933) was born and educated in Switzerland where he received his M.D. degree from the University of Bern in 1878. He came to New Philadelphia, Ohio, in 1883 to continue his medical practice and research on the smallest mollusks—Pupillidae (tiny land snails) and Sphaeriidae (fingernail clams). In 1909 he abandoned his medical practice, which had long been neglected, to become Assistant Curator of Mollusks at the Carnegie museum in Pittsburgh. From his papers deposited there, excerpts will be

read concerning such topics as: identification, classification, and nomenclature of Pupillidae, Sphaeriidae, Unionidae, and some groups of freshwater gastropods; philosophical and scientific discussions on the concept of species, "splitting" vs. "lumping" of species, the goals of taxonomy, evolution, and the organization of societies for the promotion of malacology, including the American Malacological Union.

This paper has been published in full in *Sterkiana* 63-64: 65-76, 1976.

THE DISTRIBUTION OF THE MARGARITIFERIDAE: A REVIEW AND A NEW SYNTHESIS

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Abstract

The disjunct distribution of the Margaritiferidae has long caused speculation among malacologists and biogeographers. Two classic theories have been formed in the past. In 1912 Scharff proposed that the family originated in North America and spread east and west to Eurasia and Walker in 1910 argued that the family originated in Asia and migrated east and west to North America. The Asian theory for many years has been accepted as the more correct. Furthermore, both ideas relied on continental stability and transoceanic landbridges. In addition each assumed a Cretaceous Period origin for the family.

Recent advances in plate tectonics and paleomagnetism indicate vast continental movements have occurred during the last 400 million years. Such drifting of land masses allows for a new analysis of historical distribution patterns. The dispersal of the Margaritiferidae can be interpreted by the wandering of continents, but one must first accept an earlier, mid-Paleozoic origin for the family. Evidence in the fossil record suggests modern appearing mussels were present during the upper Devonian Period. This suggests the family originated 280 million years earlier

than was previously thought.

During the mid-Paleozoic Era all the present continents were joined to form Pangaea. Within central Asia the Margaritiferidae were flourishing and spreading. In late Paleozoic Pangaea a shallow continental sea split the family into eastern and western groups. The Ural and Appalachian Mountain orogenies formed barriers limiting the dispersal of the western group, while the eastern group spread widely. In the early Mesozoic Era a rift zone developed in northeastern Asia driving the eastern population toward the coast. Propagules of this group then invaded lands formed as a result of early plate shifting. By mid-Mesozoic times the family reached its approximate present day distribution in North America, Europe, northern Africa and Asia. Rotation of Laurasia away from Gondwana at the close of the Mesozoic Era separated, North American populations from those of Europe and North Africa. Rifting in eastern Asia continued to compress and split mussel populations. In the early Cenozoic Era most of the drastic land movements ended and by the mid Cenozoic eastern Margaritiferids crossed the Behring Sea land bridge and invaded western North America.

NOTES ON UNIONACEAN MOLLUSKS OF THE RIO GRANDE SYSTEM, UNITED STATES AND MEXICO

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Abstract

Relatively few (14) species of unionacean bivalve mollusks, either living or fossil, are known from the Rio Grande (=Rio Bravo del Norte) system of the United States and Mexico. In the upper part of the system above the mouth of the Rio Conchos no native unionaceans, living or fossil, are known. This may relate to this part of

the system having originated as an internal drainage. Only two species are known from the Rio Conchos system of Mexico, suggesting that access to this part of the Rio Grande system has been difficult. The canyons of the Big Bend region contain a stream with rocky streambeds and frequent rapids. These may have been a barrier

to dispersal by species preferring siltier streambeds and calmer waters. Access to the Pecos River, with its mouth downstream from the Big Bend region, seems to have been easier. Five species are known as fossils and five others have been found living in the Pecos system. Some of these latter species may now be extinct in the Pecos system because of impoundment of its

lowermost part in Amistad Reservoir. The fauna of the Rio Salado system (Nuevo Leon and Coahuila, Mexico) is much like that of the Pecos, with ten known species. Approximately half of these may now be extinct. In the lower mainstream of the Rio Grande at least six species are still living at present and three or four additional species may occur.

ORIGIN AND AFFINITIES OF THE FRESHWATER MUSSELS (UNIONIDAE) OF SOUTHEASTERN LOUISIANA

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Abstract

Thirty-six species and subspecies of freshwater mussels (Unionidae) are found in the Lake Maurepas-Pontchartrain-Borgne drainage system of southeastern Louisiana and southwestern Mississippi. A comparison between this unionid faunal assemblage, with those of adjacent gulf coastal drainages, suggests greater affinities to the east in the Alabama-Coosa River system, where 28 of the 36 forms are represented. The analysis of present distributions and past geological events suggests that the introduction of the present fauna did not occur through the Mississippi River system. It is significant that, for 7 of the 28 species encountered in the Alabama-Coosa River system, the western limit of their range in gulf drainages is the Amite River

system. The absence of all 7 species from those Mississippi River tributaries draining western Louisiana would seem to preclude their introduction of a unionide fauna from the east includes: (1) the presence of heavy minerals of Appalachian origin in the Citronelle Formation of southeastern Louisiana and (2) a postulated Pliocene Tennessee River that flowed from northeastern to southwestern Mississippi where it entered the Mississippi Embayment. The introduction of a naiad fauna may have occurred through this Pliocene Tennessee River. Alternatively, immigration may have been accomplished through former stream confluence between the headwaters of the Pearl and Tombigbee River systems.

ELLIPTIO AT THE SCHACHT SITE, HANOVER TOWNSHIP, LUZERNE COUNTY, PENNSYLVANIA

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Abstract

For many years before white men came to the Wyoming Valley, Indians vied for control of its arable plains and its strategic location at the mid-section of the northeastern branch of the Susquehanna River. About half a century before Captain John Smith's coming in 1608, a kitchen midden was formed at the Schacht Site from the remains of numerous clam dinners and general domestic waste. There are five things which we have learned about this midden and its contents. First, Susquehannock Indians probably dug the pit. Second, it was filled with a combination of

materials and a relatively small proportion of the total volume were shells. Three, because of the absence of decayed materials such as leaf mold, the pit was probably filled in less than three years. Fourth, one could reasonably conclude that the clams came from the Susquehanna River system in the Wyoming Valley. And fifth, the present population of *E. complanatus* seems to be dramatically depleted as compared to that of the mid-1500's when the Schacht Site pit was filled with its kitchen waste.

But out of these conclusions comes a

fundamental question. That is, what does the presence of *Elliptio* clam shells at the Schacht Site mean in a larger context? We believe that the answer to this question is held in the configuration of the trench around the Indian village. We offer here an hypothetical analysis of what took place during the late prehistoric period at the Schacht Site based on cultural characteris-

tics of the supposed inhabitants. It is an ethnoconchological model which is a common denominator with which to analyze material culture. This system of analysis could then be added to other archaeological models, thus providing another tool with which to examine remains of ancient peoples.

BIVALVE MOLLUSCAN MARICULTURE

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Abstract

Mariculture, it is generally agreed, dates back to classical Roman times when oyster appetites demanded more than nature could provide without a little assistance.

This slide presentation showed modern molluscan mariculture as actually practiced around the world, featuring the world's two most

important bivalve crops—oyster and mussel culture.

The hatchery and grow-out operation developed at the Shelter Island Oyster Company was included as was a brief presentation of current molluscan mariculture research needs.

COMPARISON OF ORGANIC AND INORGANIC CONTENT OF THE SHELLS OF SOME SPHAERIID CLAMS¹

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Abstract

Freshwater habitats vary greatly in water hardness and the level of available calcium may be important for shell formation in some molluscs. In *Lymnaea peregra*, the mass of the shell varies with available calcium (Zool. Bid. Uppsala 24: 419, 1947.) In *Ferissia rivularis*, there is neither a correlation between the amount of shell CaCO_3 and water hardness nor an inverse relationship between shell mass and the amount of carbon and nitrogen in the organic matrix (as expected by an "adaptive value" hypothesis) (Science, 155: 338-340, 1967; Biol. Bull., 139: 402, 1970). Shells from eight sphaeriid clam populations (from Ohio) were studied: one population of *Pisidium walkeri* (FP, farm pond, Cuyahoga County); three populations of *Musculium partumeium* (DW, Drew Woods Pond, Darke County; CA, Cox Arboretum Pond, Montgomery County; AM, Aullwood Marsh Pond, Montgomery County); two populations of *Sphaerium simile* (WC, Wolf

Creek, Montgomery County; HC, Holes Creek, Montgomery County); one population of *Musculium transversum* (SRM, Stillwater River-north branch, Darke County); and one population of *Pisidium casertanum* (SRP, Stillwater River-north branch, Darke County).

Shells were analyzed for total organic carbon by a wet-oxidation method (Proc. Malac. Soc. Lond., 38: 1-11, 1968) and also for total nitrogen using a semiautomatic micro-Dumas nitrogen analyzer (Coleman model 29). The percentage of CaCO_3 of total shell and tissue dry weight was determined by wet ashing with 10% nitric acid. For each habitat, water conductivity was measured and water hardness determined by an EDTA (ethylenediaminetetraacetate) titration. For habitats FP, DW, CA, AM, WC, HC, SRM, and SRP, the conductivities (μMHO) are 110, 170, 289, 530, 570, 630, 790, and 790 respectively. The percent CaCO_3 of total shell and tissue dry

weights are 85.99, 85.66, 81.95, 87.15, 89.28, 90.86, 90.50, and 83.57 respectively. For habitats DW, CA, AM, WC, HC, SRM, and SRP, the CaCO_3 hardnesses (mg/l) are 80, 69, 80, 200, 206, 260, and 260, and the MgCO_3 hardnesses (mg/l) are 54, 116, 126, 183, 210, 186, and 186 respectively. For habitats FP, DW, CA, AM, WC, HC, SRM, and SRP, the shell nitrogens ($\mu\text{g N/mg shell}$) are 3.10, 2.24, 3.09, 2.50, 2.06, 1.79, 2.25, and 2.75 respectively. For habitats FP, DW, CA, AM, WC, HC, and SRP, the shell carbons ($\mu\text{g C/mg shell}$) are 7.89, 7.33, 10.76, 9.00, 5.22, 4.42, and 8.85, and the C:N values are 2.55, 3.27, 3.48, 3.60, 2.53, 2.47, and 3.22 respectively. The C:N values suggest shell matrices of pure protein (within the range of C:N values for amino acids).

There are some significant (95% confidence level) interspecific, but no intraspecific differences in the percent CaCO_3 (total shell and tissue dry weight) for the populations examined. Intraspecifically, for *M. partumeium* (DW, CA, AM) and *S. simile* (WC, HC) a limited number of populations were examined and more data would be necessary to make definitive statements about the relationship between water hardness and the percent CaCO_3 (total shell and tissue dry weight). There are significant differences (95% confidence

level) in the organic composition (C and N) of the shells of *M. partumeium* from DW and CA. However, the values for *M. partumeium* at AM are not significantly different from those of the populations at DW and CA. There are no significant differences in the levels of shell carbon and nitrogen between the populations of *S. simile* (WC, HC). For the distinct populations of the five species examined, interspecifically, there are no obvious correlations between water hardness and the percent CaCO_3 (total shell and tissue dry weight). However, inter- and intraspecifically there is an inverse relationship between shell mass (percent CaCO_3 of total shell + tissue dry weight) and the amount of carbon (linear regression: $r^2 = 0.69$; probability of $F = 0.916$) and between shell mass and the amount of nitrogen (linear regression: $r^2 = 0.49$; probability of $F = 0.784$) as expected by an "adaptive value" hypothesis. The overall data, interspecifically, strongly indicates that within the range of habitats examined, populations of sphaeriid clams build shells (CaCO_3 mass and organic matrix) which are independent of water hardness.

1 Research supported by NSF URP Grant No. 93237, grants from the University of Dayton Research Council, and the Ohio Biological Survey.

BRIEF NOTES ON A FEW SPECIES OBSERVED IN CAPTIVITY

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Abstract

(1) *Siphonaria alternata* Say, 1826.

One specimen of *Siphonaria alternata* from the Florida Keys lived in the aquarium about nine months and was observed as it fed on the algae covering the sidewall of its aquarium. It created a trail by grazing to the bare glass a line of minute spots which it followed to its grazing area and retraced to its home station even when branching trails were added. The distance between each spot of cleared glass was slightly longer than the length of the *Siphonaria*'s shell, just within anterior and posterior contact of the extended animal's mouth and mantle. Where short stretches were heavily grazed, the bare spots disappeared in a more visible clear swathe. The *Siphonaria* followed its trail back to its home station even when a direct line over unmarked territory would have been much shorter.

(2) *Melongena bicolor* (Say, 1827).

In captivity *Melongena bicolor* fed upon a number of species not native to its habitat, including *Mytilus edulis* Linne, 1758. When *Mytilus edulis* was placed at a distant area of the aquarium, *Melongena bicolor* found the prey by following the current in the water set up by the exhalant of the bivalve, even when the current ricocheted from sidewall or other obstruction to form an angle. *Melongena bicolor* attacked by thrusting its proboscis directly into the exhalant siphon of *Mytilus edulis*. However, *Melongena bicolor* was unsuccessful in its attempts to strike into the smaller and more elusive target of the exhalant valve of *Mya arenaria* Linne, 1758.

(3) *Marginella apicina* Menke, 1828.

Experiments were conducted using two highly

pigmented female *Marginella apicina* and four males of very low pigmentation, the specimens selected in order that the lots would not be confused. The males were introduced into the aquarium with the females and withdrawn after five days, after which the females deposited viable eggs for a period of thirty days. Eggs deposited after the thirty day period were infertile. The observation was repeated three times with the same results, indicating that *Marginella apicina* can retain viable sperm for about a month.

(4) *Epitonium humphreysii* (Kiener, 1838).

The adult *Epitonium humphreysii* (and *E. rupicola* (Kurtz, 1860)) fed in captivity on

anemones (*Sagartia*) by thrusting the proboscis down the mouth of the anemone into its body. Juveniles of 2 & 3 mm *Epitonium humphreysii* were observed to stay close to the base of the anemone and feed from or through the outside of the stalk while staying well out of reach of the anemone's tentacles.

Triangular capsules? Although the egg cases of *Epitonium* are described in the publications as "angular capsules," it is the shape and texture of the sand grains that cling to the capsules that give them the angular or lumpy appearance. Carefully removing the sand grains, we found the egg capsule of *E. humphreysii* to be spherical, 0.6 mm in diameter, and that of *E. rupicola* a smooth oval of similar size.

THE DEVELOPMENT OF THE LARVAL AND EARLY POSTLARVAL SHELL OF THE BAY SCALLOP, *ARGOPECTEN IRRADIANS*

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Abstract

A culture of the bay scallop, *Argopecten irradians*, was sampled at 24-hour intervals beginning 24 hours after fertilization. Scanning electron microscopy revealed the sequence of development of the hinge, ligament, and shell from the first appearance of the shell through metamorphosis.

Initial secretion of Prodissoconch I by the larval shell gland is complete before 24 hours after fertilization. By 24 hours, secretion becomes marginal and incremental, signaling the start of Prodissoconch-II stage, and larval teeth appear as low undulations at each end of the Prodissoconch-I hinge.

From 48 to 144 hours marginal growth continues along differing gradients so that the anterior end of the shell becomes narrower than the posterior. The valves remain equal in convexity, and the larval teeth increase in amplitude, offsetting shearing forces on the relatively weak ligament, which is still linear and completely organic.

By 168 hours the onset of metamorphosis is indicated by a groove which forms along the inside of the margin of the left valve. Although this groove is occupied by the edge of the right valve, the valves remain about equal in convexity. The ligament begins to thicken in the center of the hinge between the larval teeth but is still completely organic.

At metamorphosis, the irregularly prismatic aragonitic structure of the prodissoconch changes abruptly after the formation of an external ridge to foliated calcite in the left valve and prismatic calcite followed internally by foliated calcite in the right.

By 216 hours most larvae have metamorphosed and have secreted a sizeable fringe of dissoconch shell. Dissoconch shell secretion is much more rapid, and the differences in microstructure between valves allow the right valve to flex and nestle within the left during closure. The right byssal notch and fasciole also begin abruptly at metamorphosis. The embryonic resilium, still completely organic, continues to increase in size and is supported by aragonitic shelves formed as continuations of the inner surfaces of the prodissoconch.

By 240 hours, spongy lateral areas begin to form on the resilium, apparently to become the sites for the calcareous pads of the resilium later in ontogeny.

This pattern of development lends no support to the idea that the pectinid resilium has evolved from an ostreid-type resilium by decalcification of its central portion. Rather, the non-calcified portion of the pectinid structure is a relatively unmodified primary feature that appears early in the larval stage.

ECOLOGICAL STUDIES ON HALOPHILIC ELLOBIIDAE IN THE AZORES

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Abstract

The observation of seven ecologically divergent, brackish and marine, shore localities in the Azores Islands provided some conclusions about the habits of five halophilic Ellobiidae:

1. Salinity.

Salinity, by itself, seemed not to be a conditioning factor for the number of specimens and the distribution of the species; two other

factors have to be considered: (1) the accumulation of rolled stones (2) the accumulation of decaying organic matter (sea weed detritus).

2. Pollution.

Organic matter pollution (detritus) can be a stimulating factor. Detritus from the milk industry seems to be a decreasing factor. Oil is lethal.

GALAPAGOS FINCHES: CASPIAN COCKLES

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Abstract

Charles Darwin, during his famous voyage aboard the *HMS Beagle*, was startled by the remarkable finches of the Enchanted or Galapagos Islands and first began to perceive what he called that 'mystery of mysteries', the origin of distinctly unique organic units, the evolution of new species. The enthusiasm for the mystery has hardly abated and, though several generations of biologists have devoted immense attention to the subject, the dynamics of the formation of new species, indeed, the essential nature of species, remains a central issue in contemporary evolutionary biology.

The Geospizinae, or Darwin's Finches, those rather drably colored birds, were intensely investigated by several researchers, among them, David Lack, whose book, *Darwin's Finches*, has become a classic in the study of evolution. The radiation of these birds, facilitated by the geographic isolation and lack of competitors provided by the islands, culminated in over a dozen species, separable into several generic units, mostly distinguishable by their amazing adaptation to specific ecological niches, especially their preference in feeding. This trophic diversification, reflected in the differentiation of the form of the bill, ranges from diets including seeds, grains and insects to behavioral adaptations including the spectacular use of twigs as tools.

Since Darwin's elaboration of the theory of natural selection, many instances of noteworthy evolutionary radiation have been discovered. Among the Mollusca, the land snails of the Hawaiian and French Polynesian Islands, the Achatinellidae and the Partulidae, respectively, have attracted considerable attention. One unusual example among marine bivalves, involving not only rapid phyletic diversification by adaptation to rather unique salinity regimes is the radiation of the cardiids in the Ponto-Caspian basin. Today, these cockles are represented by several distinct genera in the Black, Azov, Caspian and Aral Seas. Not only do conchological features distinguish the living species, but anatomical distinctions, particularly of the siphons, indicate trophic specializations.

The fossil record provides an historical documentation of this radiation. Researchers have accorded subfamilial and even familial rank to this group of cockles, the Limnocardidae or Adacnidae. Toward the end of the Miocene, the Sarmatian Sea, a northern branch of the Tethys, extended from the vicinity of Vienna, Austria to the transcasian Aral Sea, was eventually separated from the Tethys, and isolated the cardiid stock which gave rise to the limnocardids. During the extent of the Pliocene, which is represented in the area by numerous geological sequences of strata, the original Sarmatian basin

altered physiographically by being subdivided into a number of smaller seas and changed chemically by a great freshening of water, forming, at times, a disconnected series of inland seas of varying degrees of reduced salinity. Most of the purely marine elements of the marine Sarmatian fauna became extinct, but the cardiid stock, similar to the Recent *Cardium* (*Cerastoderma*) *edule*, provided the source for the elaboration of a great diversity; some authorities recognize almost 40 genera and 4 or 5 separate subfamilies. Most of these animals became extinct by the beginning of the Pleistocene, but at least 3, *Didacna*, *Monodacna*, and *Adacna* along with *Cardium edule* survive in the seas today. *Didacna*, with about seven species, although previously widely distributed in the Ponto-Caspian-Aral basin, lives restricted to the Caspian Sea itself. *Monodacna*, showing a marked preference for lowered salinities, prefers the limans and estuaries of the great rivers which debouch into the Black, Azov, and Caspian Seas. *Adacna* (including the sometimes separated *Hypanis*), exhibiting considerable euryhalinity

lives in all the seas of the basin, including the most easterly Aral Sea. Occurring principally in brackish water, *Cardium edule* enjoys not only the broad range of the sometime Sarmatian Sea but still flourishes as well along the coasts of western Europe to the Baltic and White Seas.

These remarkable cockles and their immensely complex evolutionary history provide an example rare among bivalve mollusks of the processes of an exceptionally rapid evolutionary radiation. In this regard they are comparable to the more familiar and more intensely studied case of Darwin's Galapagos Finches. The complicated geologic events facilitated both the isolation of insular-like basins and the requisite time to allow isolated populations to diverge, establish genetic cohesiveness and form new species. Niches normally occupied by other marine bivalves were left vacant by the extinction of many marine Sarmatian mollusks during the freshening of these waters in the Pliocene and the cardiids were, in the absence of competitors, able to radiate into many of them.

LABORATORY CULTURE AND METAMORPHOSIS OF LARVAL *APLYSIA BRASILIANA* RANG (GASTROPODA, OPISTHOBRANCHIA)

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Abstract

Eggs laid by laboratory-held specimens of *Aplysia brasiliana* hatch in about 8 to 10 days. Newly hatched veligers were cultured in filtered seawater at temperatures of 21°C to 25°C. Cultures were maintained at salinities of 28 to 30 ppt and fed the unicellular algae *Isochrysis galbana*. The veliger circulatory system becomes well developed and easily visible by 14 days following hatching. Propodal extension was observed as early as 23 days. Metamorphosis was induced as early as 30 days post-hatching upon exposure to

freshly collected specimens of the red seaweed *Callithamnion byssoides*. Specimens could be retained in culture for as long as 70 days prior to their exposure to *Callithamnion* and subsequent metamorphosis. Propodal attachment, loss of the velar cilia, and retraction of the velar folds signal the onset of metamorphosis. Feeding begins at 5 days following settlement. This is followed by a rapid increase in growth rate. Sexual maturity is attained at about 2 to 3 months post-metamorphosis depending upon food availability.

MICROMOLLUSCS OF THE CONTINENTAL SHELF, NORTHEASTERN GULF OF MEXICO

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Abstract

The Bureau of Land Management, a federal agency, undertook a survey of the shallow shelf, northeastern Gulf of Mexico, in 1974. The work

was expanded to include the deeper part of the shelf in 1975-76. The micromolluscs, species attaining a length of no more than seven

millimeters, were a part of this project.

The area off the Mississippi-Alabama coast is dominated by clastic sediments and turbid waters, especially in the shallow part. The water is clear and there is a considerable amount of CaCO_3 in the sediment in the area east of the head of the DeSoto Canyon. The percentage of CaCO_3 increases to the east, southeast, and south along the Florida coast, especially in the fine fraction. Hard bottom with corals, sponges, and other attached flora and fauna is found on the Florida Middle Ground.

The sampling method obtained few living micromolluscs, so most of the observations were based on empty shells. More than 25,000 specimens were identified, many of them drilled or broken by predators. Filter feeding bivalves

and browsing gastropods are nearly equal in numbers on the shallow shelf in the southern half of the study area, but browsers almost disappear in turbid waters off the Mississippi-Alabama coast. Browsing gastropods are rare on the deep shelf, and the most numerous molluscs are *Bathyrca*, *Vesicomya*, and other deep dwelling bivalves.

The most common gastropods were *Finella dubia*, *Caecum pulchellum*, and *Meioceras cubitatum*, all browsers in shallow water. There was no abundant deeper water gastropod. The most important bivalves were *Parvilucina multilineata* and *Gouldia cerina* in shallow or moderate depths, and *Vesicomya pilula* out near the shelf edge.

POLYMORPHISM, CLIMATE AND BIOME DEVELOPMENT, A HYPOTHESIS

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Abstract

A hypothesis is proposed, using apostatic selection, which seeks to partially account for the contrasting variability, bright coloration and conspicuous sculptoring seen in many tropical

molluscs. It postulates that the importance of apostatic selection increases with biome maturation and that that process produces different effects in simple and complex communities.

MOLLUSKS OF BADLANDS NATIONAL MONUMENT, SD

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Abstract

Twenty seven species in fourteen genera of living mollusks were found within the boundaries of Badlands National Monument, SD, during the summers of 1975-1976. The Badlands, elevation 700-990 meters, is an area of loess overlying loosely consolidated mudstone, siltstone and more resistant sandstone. The spectacularly eroded surfaces are nearly bare of plants. As the ridges are undermined, they slump to create hummocky pockets that trap water. Sparse stands of *Juniperus* and shrubs and tiny ponds occur here and are the habitats of land and freshwater snails.

There are no natural lakes. Creeks are intermittent and most of the stock ponds dry by

the end of August. Runoff carries a heavy load of silt. Each spring and pond, isolated from the others and from any flowing water, contains a different assemblage of snails. They were most likely populated by adventitious colonization. The heavy burden of silt in the water prevents bivalves from surviving. Only two dead shells of two different *Sphaerium* and one of *Pisidium* were found.

There are no endemic species; land snails present are ones found in surrounding plains. *Succinea vaginacantorta* is dominant and abundant on the prairie. *Oreohelix*, present in the Black Hills 160 km west of the Badlands, does not occur in the Juniper stands. The low annual rainfall of

40 cm, temperatures ranging from 44°C to -40°C, intermittent creeks and high erosional rates combine with the resulting dearth of plants to limit severely the mollusks inhabiting the Badlands.

The following is a list of Badlands mollusks:

Zonitoides arboreus Say 1816
Deroceras laeve Müller 1774
Succinea avara Say 1824
Succinea vaginacontorta Lee 1951
Gastrocopta armifera Say 1821
Gastrocopta pellucida hordeaceella Pilsbry 1890
Pupoides albilabris C.B. Adams 1841
Pupilla blandi Morse 1865
Vallonia parvula Sterki 1893
Vallonia gracilicosta Reinhardt 1883
Vallonia albula Sterki 1893

Vallonia cyclophorella Sterki 1892
Pisidium casertanum Poli 1795
Sphaerium lacustre rykholti Normand 1844
Sphaerium partumeium Say 1822
Lymnaea bulimoides cockerelli Pilsbry & Ferriss 1906
Lymnaea caperata Say 1829
Lymnaea elodes Say 1821
Lymnaea reflexa Say 1821
Physa gyrina Say 1821
Gyraulus circumstriatus Tryon 1866
Gyraulus parvus Say 1817
Promenetus exacuus Say 1821
Promenetus umbilicatus Cockerell 1887
Helisoma anceps Menke 1831
Helisoma trivolvis Say 1817
Helisoma trivolvis subcrenatum Carpenter 1856

LAND SNAIL DISTRIBUTION IN REMNANT NATURAL AREAS IN THE LOWER RIO GRANDE VALLEY, TEXAS

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Abstract

The original habitat of the subtropical Rio Grande Valley has been reduced to a few remnant stands by agricultural clearing. The Rio Grande plain originally supported a mosaic of dry subtropical thornscrub and grassland. The sparse land snail fauna of remnant tracts includes *Rabdotus alternatus* (Say), *Rabdotus dealbatus* (Say), *Polygyra texasiana* (Moricand), *Polygyra scintilla* Pilsbry and Hubricht, *Praticolella pachyloma* (Menke), and *Praticolella berlandieriana* (Moricand). At any single station the fauna usually includes the two *Rabdotus*, a *Polygyra*, and a *Praticolella*.

Watercourses and the extensive floodplain of the Rio Grande supported an ecotonal woodland composed of a mixture of elements from the tropical thorn forest of Tamaulipas and the temperate bottomland hardwood forest of Texas. Tropical elements in the fauna of the surviving stands include *Gastrocopta riograndensis* (Pilsbry

and Vanatta), *Euglandina texasiana* (Pfeiffer), *Rabdotus alternatus* (Say), *Polygyra scintilla* Pilsbry and Hubricht, *Praticolella griseola* (Pfeiffer), *Praticolella berlandieriana* (Moricand), and *Thysanophora plagioptrycha* (Shuttleworth). Species of northern origin include **Helicina orbiculata* (Say), *Pupoides albilabris* (Adams), *Gastrocopta contracta* (Say), *Gastrocopta pentodon* (Say), **Strobilops texasiana* (Pilsbry and Ferriss), *Helicodiscus singleyanus* (Pilsbry), **Glyphyalinia umbilicata* (Singley), **Hawaiia minuscula* (Binney), **Zonitoides arboreus* (Say), **Euconulus chersinus trochulus* (Reinhardt), *Polygyra texasiana* (Moricand) and *Praticolella pachyloma* (Menke). Species preceded by an asterisk seem to occur in the valley as Pleistocene relicts. *Gastrocopta pellucida* (Pfeiffer), *Rabdotus dealbatus* (Say), *Succinea lateola* (Gould), *Succinea solatra* (Hubricht), and *Thysanophora horni* (Gabb) are widespread or have otherwise ambiguous distri-

ENERGY CONTENT OF PARASITIZED (TREMATODE) AND NON-PARASITIZED
SUCCINEA OVALIS (GASTROPODA: PULMONATA, TREMATODA:
 LEUCOCHLORIDIIDAE)¹

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Abstract

Parasitized and non-parasitized *Succinea ovalis* from Cedar Bog near Urbana, Ohio have been examined to determine what effect that the trematode parasite *Leucochloridium variae* has on the energy content of its host. *S. ovalis* is the intermediate host for *L. variae* whose adult is found in the hind gut of birds. The broodsac of *L. variae* extends into the hemocoel of the tentacle(s) of *S. ovalis* and is easily seen pulsating up to 3+ meters. Only those snails with this advanced state of parasitism were analyzed.

Body tissue and shell of adult parasitized and non-parasitized *S. ovalis* and broodsacs of *L. variae* have been analyzed for carbon using a wet-oxidation method [*Proc. Malac. Soc. Lond.* 38: 1-11, 1968] and for nitrogen using a semiautomatic micro-Dumas analyzer (Coleman Model 29). Mean = $\mu\text{g C/mg dry wt}$ of component (body tissue and shell) of non-parasitized *S. ovalis* of mean size 16.42 mm (12.4 - 18.1 mm) is 362.54 $\mu\text{g C/mg}$ and 6.74 $\mu\text{g C/mg}$ respectively, whereas the mean = $\mu\text{g C/mg dry wt}$ of component (body and shell of parasitized *S. ovalis* and broodsac of *L. variae*] for snails of mean size 14.84 mm (11.3 - 16.9 mm) is 418.27 $\mu\text{g C/mg}$, 9.49 $\mu\text{g C/mg}$, and 502.00 $\mu\text{g C/mg}$ respectively. Mean = $\mu\text{g N/mg dry wt}$ of component (body tissue and shell) of non-parasitized *S. ovalis* of mean size 14.75 mm (11.2 - 18.2 mm) is 107.64 $\mu\text{g N/mg}$ and 4.14 $\mu\text{g N/mg}$ whereas the mean = $\mu\text{g N/mg dry wt}$ of component (body and shell of parasitized *S. ovalis*

and broodsac of *L. variae*] for snails of mean size 15.13 mm (12.3 - 17.9 mm) is 113.46 $\mu\text{g N/mg}$, 3.58 $\mu\text{g N/mg}$ and 34.86 $\mu\text{g N/mg}$ respectively.

The mean = $\mu\text{g C/mg dry wt}$ for non-parasitized *S. ovalis* (shell + body), parasitized *S. ovalis* (shell + body + broodsac) were used to calculate C:N ratios of 3.44, 4.89 and 5.20 respectively. The C:N ratio for the broodsac alone is 6.47.

Data on snails of comparable size suggests that parasitism is detrimental to the relative quality of the host tissue. Even though the C:N ration for the body and shell of the parasitized snail is higher than that for the non-parasitized snail, the difference is due to a lower total $\mu\text{g N/mg dry wt}$ (body + shell) suggesting that the parasite derives its proteinaceous material at the expense of the quality of the host's composition.

Not only is the broodsac's nitrogen content almost twice that of the host (77.55 $\mu\text{g N/mg dry wt}$ for broodsac and 47.51 $\mu\text{g N/mg dry wt}$ for body + shell of non-parasitized *S. ovalis*), the C:N ratio of 6.47 for the broodsac indicates that the parasite is utilizing compounds other than the host's protein such as fats and/or carbohydrates.

¹ Supported by grants from The University of Dayton Research Council and The Ohio Biological Survey.

PHYLLONOTUS (GASTROPODA, MURICIDAE), A WORLDWIDE TROPICAL AND
 SUBTROPICAL GENUS

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Abstract

Of all muricid genera, few exhibit such large shell size and prominent coloration as *Phyllonotus* Swainson, 1833 (type species: *Murex imperialis* Swainson, 1833 [= *Murex margaritensis* Abbott, 1958]. Although unquestionably more

richly represented in the New World tropics, *Phyllonotus* is now considered, on the basis of a re-evaluation of worldwide muricid species, to have several species outside of the New World.

The shell in *Phyllonotus* is large, solid, and

globose. The inner lip is smooth and expanded anteriorly into a detached, erect inductura. Shells of most species bear three broad spiral brown bands and the apertural margin is heavily enameled in shades of pink, orange, yellow, or brown, or a combination of two or more of these colors. Radular dentition is typically muricine, with a simple, broad, curved rachidian tooth bearing five prominent cusps. The lateral cusps have broadly concave outer margins; the central cusp is long, obelisk-shaped, and lacks the central, longitudinal highlight indicative of a

triangular cross-section, as found in *Hexaplex*, *Chicoreus*, and *Muricanthus*.

There are two different protoconchs: a simple, short, smooth one, as in *P. pomum*, and a longer, more tapering, pustulose one, as in *P. peratus*.

In addition to the New World species generally assigned here, our investigation has led us to also assign the west African "*Murex*" *duplex*, the Mediterranean "*M.*" *trunculus*, and the Indo-west Pacific "*M.*" *superbus*, "*M.*" *laciniatus*, and "*M.*" *venustus* to *Phyllonotus*.

SURVIVAL OF *TRIODOPSIS ALBOLABRIS* IN A FIRE-TYPE HABITAT

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Abstract

Triodopsis albolabris (Say) from a mixed hardwoods-pine forest in southern Georgia are being studied to determine what factors promote survival in this annually burned habitat. Current field observations suggest that survival of individual snails during a burn is effected by a combination of 3 factors: location of the snail, intensity of the fire, and the tendency of fire to burn in a mosaic pattern; i.e., the area is not burned clean and some vegetation and litter remain. Mortality is highest among snails found under the vegetation and leaf litter; attempts to escape from approaching flames were not

observed to occur. Snails under logs, in stump or root holes or behind the loose bark of rotting stumps generally survived the burn.

Laboratory and field observations on the reproductive habits of *T. albolabris* have shown: (1) egg clutches averaging 66.2 eggs (range: 17-107) are deposited in soil or soft, rotting wood during the spring and summer months, which affords protection from fire, (2) Adult snails lay an average of 2.2 clutches per year (range: 1-7, and (3) incubation requires approximately 3 weeks; and (4) maturation occurs within 10-12 months.

NON-MARINE MOLLUSKS AND PALEOENVIRONMENTS OF THE PALEOCENE FORT UNION GROUP, NORTH DAKOTA AND MONTANA

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Abstract

Early Tertiary non-marine Mollusca and continental strata in North America were first extensively studied in the Williston Basin of North Dakota and Montana by F. B. Meek and F. V. Hayden in the 2850's. Meek (1876, U.S. Geol. Surv. Terr. - Hayden Surv. 9) provided the only comprehensive study of this classic non-marine molluscan fauna. Since 1971, the systematics, stratigraphic distribution, and paleoecology of 94 molluscan faunules have been analyzed. The

fauna consists of 40 taxa, 3 Unionidae, 6 Pisiidae, 1 Corbulidae, 13 Viviparidae, 6 other aquatic prosobranchs, 5 aquatic pulmonates, and 5 land snails.

The non-marine Paleocene of the Williston Basin includes in ascending order, the Ludlow Formation and its equivalents, the Tongue River, Sentinel Butte, and lower Golden Valley Formations. All but the Golden Valley Formation comprise the Fort Union Group. While several

alluvial environments of deposition are recognized in the sequence, there are only two molluscan facies - channel and floodbasin. Channel sediments including bar and channel bed deposits have produced infrequent occurrences of molluscan fossils but faunules are often rich in diversity and numbers of individuals. However, only four freshwater species occur predominately in channel deposits. In addition, five land snails, *Grangerella mcleodensis* (Russell), *Oreohelix grangeri* Cockerell and Henderson, *Oreohelix* cf. *W. obtusata* (Whiteaves), *Oreohelix angulifera* (Whiteaves), and ? *Macrocyclis spatiosa* (Meek and Hayden), appear as allochthones in channel sediments. The terrestrial species, better known from other early Tertiary strata in the Rocky Mountain region, have been found only in the lower Tongue River Formation and represent the first record of land snails in the Williston Basin Paleocene. Natural levee deposits, or overbank silts and sands, contain faunules that often include one or more "channel species" and show signs of transport. Such units are sedimentary and paleontologic extensions of the channel environment. Floodbasin deposits include sediments that accumulated in a range of lentic environments such as mud flats, marshes, and

pools of various size, and abandoned channels. Ten freshwater species characterize floodbasin assemblages. Sixteen freshwater mollusks commonly occur both in channel and floodbasin units, and 5 are too rare to permit analysis of their habitat preference. Slight differences between faunules from channel and floodbasin sediments and the greater number of species restricted to lentic habitats suggest that slow-moving Paleocene streams and associated interfluvial bodies provided similar molluscan habitat for a predominantly lentic fauna.

Changes in molluscan taxonomic diversity through the Paleocene probably reflect fluctuations in the extent and stability of floodbasin environments. In the middle and upper Tongue River Formation molluscan diversity reaches a zenith and sedimentological evidence suggests that interfluvial aquatic environments were both extensive and relatively stable during this interval. Declining taxonomic diversity in the late Paleocene (Sentinel Butte and lower Golden Valley Formations) was probably in response to changes in the alluvial system, although a deteriorating climate, as inferred from declining taxonomic diversity in plant microfossils, may have influenced the molluscan fauna.

THE OCCURRENCE OF TWO EUROPEAN SUCCINEIDS, *SUCCINEA OBLONG* AND *SUCCINEA PUTRIS*, IN NORTH AMERICA

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Abstract

Succinea oblonga and *Succinea putris*, two common succineids of Europe, have been found in eastern North America. The snails and their colonies are described, and the known history of

the colonies discussed. The possibility that *S. putris* may be a glacial relict in eastern North America is discussed.

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SYMPOSIUM:

CURRENT TRENDS IN MALACOLOGY

ORGANIZER: Dr. Dorothea S. Franzen

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GEORGE M. DAVIS

CURRENT TRENDS IN MOLLUSCAN SYSTEMATICS:
METHODS, TECHNIQUES
(No Abstract Available)

A. BYRON LEONARD

PROBLEMS OF ESTIMATING POPULATIONS OF
FOSSIL MOLLUSCS
(No Abstract Available)

MOLLUSCAN GENETICS AND HOST-PARASITE RELATIONS

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Mollusks serve as intermediate hosts and vectors of parasitic diseases of man such as schistosomiasis. The planorbid freshwater snail *Biomphalaria glabrata* is one of the major intermediate hosts for *Schistosoma mansoni*. It is hoped that genetic manipulation of *B. glabrata* may provide means of reducing transmission of *S. mansoni* as an alternative to the use of chemical molluscicides.

Through testing by exposing snails to miracidia of *S. mansoni*, and selection, a variety of genetic stocks of *B. glabrata* were developed with respect to susceptibility to infection. These include stocks of *B. glabrata* which test completely refractory to all strains of *S. mansoni* to which they have been exposed. Introduction of such snails into populations of susceptible *B. glabrata* in endemic areas might result in reduced transmission of schistosomiasis.

Studies are in progress to explain the basic mechanisms by which refractory snails destroy the miracidia that penetrate and by which successful miracidia penetrating a susceptible

snail avoid recognition and develop without host reaction. The amebocytes in the hemolymph appear to be the main defense of the snails. These amebocytes normally have the specific ability to recognize each other as "self" and are compatible. They have the non-specific ability to recognize foreign objects as "non-self". Foreign objects that are small enough are phagocytized by the amebocytes and larger objects are encapsulated. Successful miracidia of *S. mansoni* penetrating *B. glabrata* have some means of masking the fact they are foreign objects and developing without tissue reaction by the host snail.

An amebocyte-producing organ occurs in the anterior pericardial wall of *B. glabrata*. This organ is inapparent in normal unstressed snails, but becomes activated in production of amebocytes under certain conditions of stress; infections, genetic abnormalities, etc. Amebocytes of *B. glabrata* can survive *in vitro*, without multiplication, for several months, and in the absence of stress may survive in the living snail throughout the snail's life span.

MALACOLOGY AND PARASITOLOGY AS THEY PERTAIN TO HEALTH

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Work involving snails in relation to health has been carried out over an extended period at many laboratories both at home and abroad. Among those most active abroad are investigators such as Dr. G. Mandahl-Barth in Copenhagen, Professor J. Lever and the group in the Free University at Amsterdam, Dr. C.A. Wright in the University of London, Professor J.A. Van Eeden in South Africa, Dr. Emile Demian in Cairo, Drs. C.T. Lo and John Cross at NAMRU-2 in Taiwan, and the Tropical Medical Laboratory in Bangkok. In the

United States, active centers include: Drs. Michelson and Chernin at the Harvard Public Health School; Dr. Lewert in the University of Chicago; Dr. Lois Wong Chi at California State College; Dr. Emile A. Malek at Tulane; Dr. Charles Richards at N.I.H. in Washington; and the group in the University of Michigan's Museum of Zoology.

Since human trematode cycles were first established in the laboratories at the University of Michigan in 1967, it has been possible to build

what essentially is a Medical Malacology Institute. This facility has been active with sponsorship from the Geographic Medicine group in the NIH (supported by the Japan-U.S. Agreement funds) for nine years; it now enters the last of a second five-year program. With about 9,000 square feet of space given to maintaining the snail cultures and animal facilities to provide mice, hamsters and dogs to carry the human schistosome infections, this laboratory supplies the basic research materials in schistosomes to some 65 laboratories. With funds from the Armed Forces Research and Development Command, now terminating after 24 years of support, much of the basic research in learning how to culture intermediate host snails was undertaken. In brief, the schistosome supply work enabled the operation and establishment of a facility and staff; other grants-in-aid (such as the Army R and D) provided staff and facility for the research needed to study culturing snails, their morphology, ecology, life-histories, and other studies.

The Mollusk Division was fortunate to have had the support of an NIH Training Grant which extended over a 15-year period and ended in 1974 when those grants were terminated. Essentially this support remained the means for training most of the malacologists studying at the University of Michigan. The list of those receiving such support is a long one since there were usually four graduate students active in malacological studies each of the years in which that support was available. Some difficulties developed because the administration of the program, primarily in Zoology had to function to include at least two other schools—Public Health and Natural Resources. While functionally there is no conflict, most schools have not yet developed programs that make working along *interdisciplinary* lines anything but a difficult procedure.

Malacological programs that concern us and relate to medical malacology in foreign countries will be discussed and illustrated by kodachrome slides, focusing on some of the problems posed by intermediate snail hosts in the control of human blood fluke (schistosomiasis or bilharziasis). The countries featured are those with which our laboratory has had some immediate contact, but they are just a few among the many awaiting basic malacological studies. In the Orient the pictures show sites of infection with *Schistosoma japonicum* in Japan, Taiwan and the Philippines.

A new focus with a *S. japonicum*-like trematode was discovered a few years ago in the Mekong. We have been fortunate to be able to establish that new cycle in our laboratory with the assistance of Drs. Liang, Kitikoon, Bruce, Schneider and others. It has been encouraging to learn that in using this cycle as supplied from our laboratory, Drs. Ernest Bueding and John Bruce now appear to have a drug that is both prophylactic and curative. In Africa, the problems in Egypt have been compounded with the building of the new High Dam; in the Sudan, the Gezira scheme for increasing agricultural acreage has grown from one million acres to include eventually three million between the Blue and White Nile south of Khartoum, and the struggle to control blood fluke there becomes increasingly more difficult.

While the biology of exotic snails in relation to health has been, and will continue to be, a concern of malacologists, the large increase in swimmer's itch (schistosome dermatitis) in the Great Lakes and other regions has not been discounted. At present, three of the most important non-human schistosomes are being maintained in cycle in our laboratory: the mammal schistosome, *Schistosomatium douthitti*; two bird schistosomes, *Gigantobilharzia huronensis* (with adult worms in goldfinches, blackbirds, etc.) and *Trichobilharzia ocellata* (in duck-like birds). A thesis in press by Dr. Robert Wall shows that at least a hundred lakes in Michigan are reported each year to be infested with schistosome dermatitis; a conservative estimate is that five times that many are at least periodically infested but not reported. Studies undertaken are, surprisingly enough, not supported by tourism—one of Michigan's largest industries!

While basic malacology has been encouraged and supported by schools and various governmental agencies, as well as the World Health Organization, much more support for study and research will be needed if there is going to be any reasonable amount of control of serious diseases by means of eliminating snail intermediate hosts. Such studies must be far more interdisciplinary than hitherto anticipated. A recent example of a lack of support across fields is the failure to sponsor the use of pulmonate snails for *focal* control of increased ambient temperatures caused by solarators. Sanitary engineers are not prepared to supply the needed expertise to make such a control program possible. Data derived

from a 3-year program designed to measure growth and reproduction in pulmonate snails clearly showed that at 30°C or higher pond snails will not produce eggs. This prospective method of control now awaits pilot field tests.

In the epidemiology of schistosomiasis and other snail-borne diseases, far too little is

expended both in funds and effort to find suitable methods of snail control. More properly trained malacologists are needed, and hopefully agencies responsible for developing control methods will encourage more basic studies necessary to find suitable means for snail control.

PROCEDURES AND METHODS IN MOLLUSCAN CYTOLOGY AND CYTOGENETICS

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Chromosome study of molluscs is of special interest to the cytologist because of the extreme diversity in morphology, anatomy, number of species, and a number of other qualities. The earlier reports on molluscan chromosomes are largely unreliable, as these workers mostly used the paraffin sectioning technique (Burch, 1965). This method does not reveal chromosome morphology clearly, compared to the squash technique. Although acetic carmine was reported as a stain fixative in 1921 by Belling (cited by Sharma and Sharma, 1972), for a long time the squash technique was not adopted by molluscan cytologists. Husted and Burch (1945) used the squash technique along with paraffin sectioning on polygyrid snails. In subsequent years many workers switched to the squash technique to study chromosomes of molluscs. Once this switch from sectioning to squashing was made, the study of molluscan chromosomes became easy and rewarding. Moreover, a wealth of reports on chromosome numbers of molluscs has appeared in the literature during the past 26 years (see Burch, 1965; and Patterson, 1969, for reviews).

Unfortunately, studies of karyotype analysis of molluscs are very few. Burch (1968) has correctly stated that the rarity of molluscan karyotype analyses is not due to lack of their value, but rather to the technical difficulties in obtaining adequate chromosome preparations.

In this paper, we wish to point out to those interested in molluscan cytology and cytogenetics that one can overcome such technical difficulties by utilization of the available techniques or by modifications of these to suit particular needs.

The testes or ovotestes of snails are good sources of meiotic and mitotic chromosomes. However, it is necessary to know something about the reproductive cycle of the species in question. Both meiotic and mitotic chromosome preparations can be obtained in abundance before the breeding period. Generally, meiotic and mitotic divisions in snails follow the wave pattern observed in vertebrates, (i.e., at any given time one can observe mitotic metaphases, meiotic prophase I, metaphase I or metaphase II in the squash preparations of testes or ovotestes). However, if one obtains specimens from the field and natural time factors must be considered, then it is usually a matter of "luck" in obtaining both meiotic and mitotic chromosomes. This is especially true if the snails are scarce and difficult to obtain in large numbers.

An excellent and inexpensive source of mitotic chromosomes is snail embryos. These grow rapidly once the egg capsules are laid. A properly maintained breeding colony of snails can provide abundant embryos for many months.

An additional source of chromosomal material is tissue culture. Unfortunately, this has not been widely used. Originally, it was worked out by Burch and Cuadros (1965), and applied to karyotype analysis by Burch (1968). The only limiting factor in Burch and Cuadros' technique is the great number of snails necessary to prepare the "snail extract".

One of us has tested a number of synthetic culture media for growth using foot tissue of *Helix aspersa* (S. Samsam, unpublished). After many trials, it was found that Ham's F-10 medium supplemented with 10% fetal calf serum and 1 ml of antibiotic-antimycotic solution per 100 ml of

medium gave good preliminary results.

Further investigation on snail tissue culture using synthetic media is necessary. A simple and inexpensive tissue culture technique for snails would open up an entirely new field of molluscan chromosome research.

Preparation of Chromosome Spreads

1. From ovotestes or testes:

Both mitotic and meiotic chromosome spreads can be made by using the hypotonic squash technique (Babrakzai and Miller, 1974; Stern, 1975). Temporary mounts can be made permanent by: (a) freezing them in dry ice; (b) removing the coverslip with a razor blade; (c) dehydrating them in a graded series of ethyl alcohols (70-100%); and (d) mounting a fresh coverslip on the slide with Euparal and mounting the old coverslip on a new slide in the same way. However, it is recommended that chromosome spreads be studied before making the squash preparations permanent as some loss of material does occur.

2. From embryos:

A technique using freshwater snail embryos was first reported by Patterson (1971). We have developed the following modification of this technique suitable for land snail embryos:

a. Collect the snails from their habitat just before their breeding season. This is usually early spring if they have seasonal reproductive cycles.

b. Maintain the snails in terraria containing leaf litter, rocks, etc., from their natural habitat, and keep them in humid conditions, feeding them romaine lettuce twice a week.

c. After 2-3 weeks remove all snails from the terraria and gently search the litter thoroughly for egg clutches. Snails have a tendency to bury their eggs beneath the litter. Carefully and gently collect the eggs using a small spatula, and place them on a moist paper towel.

d. Gently wash the eggs in tap water to remove sand and debris. Place the clean eggs again on a moist paper towel, wrap them up gently and place them in a covered petri dish.

e. Label each petri dish with the species name, date, etc. Keep these in a moist humid place (a terrarium is fine) at room temperature.

f. Incubate for 5-12 days. After the 5th day dissect one or two eggs on a slide under a dissecting microscope. We have found that

embryos having a good number of mitotic metaphases are usually about 1-1.5 mm in diameter, or when they have the shell rudiment present.

g. Search the terraria for eggs 2-3 times a week, and be certain to feed the snails.

h. Dissect all the egg capsules with fine forceps, after the proper incubation period. Do this under a dissecting microscope in a watch glass containing hypotonic-colchicine solution (0.075 M KCl and 10^{-4} M colchicine). Release the embryo from the egg capsule.

i. Remove the embryos using a Pasteur pipette and wash them in a watch glass containing hypotonic colchicine solution to remove the albumin.

j. Incubate the embryos at room temperature in the hypotonic-colchicine solution in a watch glass for 60-90 minutes, or more if desired. This incubation time is critical. Overtreatment results in extremely contracted chromosomes, and undertreatment will not arrest metaphase. The hypotonic solution swells the cells, and thus helps the chromosomes to untangle and spread. If very condensed chromosomes are observed, then dissect the eggs in the hypotonic solution without colchicine. Incubate them for 30-45 minutes in fresh hypotonic solution, followed by incubation in hypotonic-colchicine. In favorable spreads the two chromatids of each chromosome should not be separate, otherwise such spreads do not give satisfactory results when subjected to G or C banding techniques.

k. Fix the embryos in freshly prepared methanol: acetic acid (3:1) for 30 minutes.

l. After fixation transfer the embryos to 45% acetic acid for 15 minutes or more. This step removes the methanol from the embryos and also softens them.

m. Place one embryo on a clean slide with a small drop of 45% acetic acid. Tease the embryo with fine insect needles to loosen its cells, place the cover slip on top of the drop, and squash on a paper towel. The coverslip should face down during squashing.

n. Label the slide on the right hand corner with a diamond pencil for future identification and for use as a reference point.

o. Freeze the slides thus prepared on dry ice for 1-2 minutes and remove the cover slip using a razor blade.

p. Dehydrate the slides in a graded series of 70-100% ethanols.

q. Store the slide in a clean slide box after drying.

r. For routine chromosome study, stain the slides in 1% lactic-acetic orcein (Cooperrider and Morrison, 1967) for 10-15 minutes. Rinse these in tap water; dehydrate them in graded ethyl alcohols (70-100%); and mount them in Euparal.

s. The stored slides (from step "q" above) can be used for G-banding, C-banding and NOR techniques (see below).

3. From tissue cultures:

Once good tissue cultures are obtained and maintained, the technique for preparing chromosome spreads is a standard one, and the reader is referred to Burch (1968) and Schwarzscher (1974a) for details and additional references.

Karyotype Analysis

1. The Classical Karyotype:

Classically, a karyotype consists of describing the number, morphology and arrangement of the homologous pairs of mitotic metaphase chromosomes of a species in order of their length.

There has been considerable confusion in the terminology used to describe the morphology of chromosomes. In order to minimize this confusion we have followed the scheme of Levan et al. (1964). The methods of Bogart (1970) and Raicu et al. (1973) for the comparison of karyotypes and the construction of idiograms are useful. These have been used to compare the karyotypes of Oreohellicidae (Babrakzai, Miller and Ward, 1975), Helminthoglyptidae (Babrakzai, 1975), and Polygyridae (Reeder, 1975).

Not all homologous chromosome pairs can be identified precisely. This is especially true if there are many chromosome pairs with almost identical lengths and centromeric positions. At best the chromosome pairs can be identified statistically from a large sample. Nonetheless, a classical karyotype is very important to have on hand for reference, and is very useful in preliminary studies. An example of this is the karyotype of the Bradybaenid, *Bradybaena similis*, versus the karyotypes of Helminthoglyptid species (Babrakzai and Miller, 1976).

2. Chromosome Banding Techniques and the Karyotype:

The difficulty in the identification of homo-

logous chromosomes in metaphase has been largely eliminated by the development of chromosome banding techniques. These techniques have been developed during the past 6-7 years by mammalian and human cytogeneticists. As it turns out they can also be applied to molluscan cytology (Babrakzai, Ward and Miller, 1976). Essentially, the new banding techniques fall into the following categories:

a. Fluorescent bands of chromosomes (Q-bands, so-called for the quinacrine stain).

b. Giemsa bands of chromosomes (G-bands).

c. Centromeric bands of chromosomes (C-bands).

To the best of our knowledge fluorescent banding techniques have not been applied in the analysis of molluscan karyotypes. Usually, the G-bands and Q-bands of a particular set of chromosomes are identical.

Various chemical treatments such as trypsin, 2 x SSC (0.3 M NaCl and 0.03 M sodium citrate), urea, sodium hydroxide, potassium permanganate, etc., induce G-bands. The technique of Sumner et al., (1971) has been successful with land snail chromosomes in our laboratory. The chromosomes, after pretreatment, are differentiated in Giemsa stain. Some parts of a chromosome are stained darkly and others are not. These chromosome "bands", or G-bands, act as landmarks for the identification of homologous chromosome pairs. The banding pattern of each homologous chromosome is unique and is constant for a species or a group of closely related species. Thus, such techniques allow one to construct a precise karyotype for each species, and this can be used as a comparison with others. Furthermore, chromosomal aberrations such as inversions, translocation heterozygosity, etc., can easily be detected. The mechanism of G-band induction is currently under investigation by a number of workers.

Centromeric bands (C-bands) are obtained after denaturing the DNA in sodium or barium hydroxide. This is followed by incubation in hot saline citrate (60°C) for one hour or more. After staining in Giemsa, the constitutive heterochromatin, often located around the centromeres but occasionally located interstitially or terminally, is stained darkly. We have found that 6-10 day old slides are suitable for G and C banding techniques of land snail embryos. The BSG technique of Sumner (1972) has given us very satisfactory

results. However, for land snail chromosomes, staining for 5-20 minutes in Giemsa gives satisfactory results compared to 60-90 minutes recommended by other workers.

The C-banded karyotype further facilitates karyotype comparisons, and identifies pericentric inversions and centric chromosomes. Moreover, since G and C bands are inherent parts of chromosome morphology of each species, banded karyotypes are essential in clarifying relationships between closely related species. Theoretically, it is possible to trace individual chromosomes from species to species through their G and C banding patterns, and thus observe karyotype evolution at a resolution never before achieved in molluscs. For details of techniques of Q, G and C banding see Schwarzbacher (1974b) and Schnedl (1974).

3. The NOR Technique:

The nucleolar organizer region (NOR), which is usually seen as a secondary constriction in metaphase chromosomes, is another subject of current research. Denton and Howell (1975) have demonstrated that silver nitrate and ammoniacal silver stains the NOR differentially.

4. The Haploid Karyotype and Analysis of Meiosis:

An important aspect of cytology and cytogenetics is the study of the meiotic chromosomes of a species. During the long prophase of meiosis, the homologous chromosomes pair (synapse), form chiasmata, gradually condense and disjoin at metaphase I. Abnormalities in the karyotype (e.g., inversions, translocations, trisomies of various kinds, supernumerary chromosomes, univalents, isochromosomes, etc.) can usually be detected during prophase and metaphase I of meiosis. This information comprises an important supplement to the karyotype constructed from mitotic metaphase chromosomes of the same species. The behavior of chromosomes at metaphase I and metaphase II should also be observed whenever preparations are favorable.

Chromosomal aberrations are not uncommon in species of land snails. Chromosome fragments, trisomy and translocations are common in *Sonorella virilis* (Babrakzai, Samsam and Miller, 1976), *S. odorata*, *S. simmonsii*, *Monadenia infumata*, *Helminthoglypta fisheri* (Helminthoglyptidae), *Ashmunella chiricahuana* and *A. lenticula* (Polygyridae), and *Radiocentrum chiricahuana* (Oreohellicidae) (Babrakzai, Reeder and Miller, 1975).

If it had not been for the analysis of the meiotic karyotype, the chromosome number of *Sonorella virilis* could not have been determined accurately. Earlier it was incorrectly reported by one of us that the chromosome number in *Sonorella* is $n=30$ (Babrakzai, 1975; Babrakzai, Reeder and Miller, 1975). The correct haploid number for the genus *Sonorella* and the subfamily Sonorellinae is $n=29$.

5. Endopolyploidy:

Endopolyploidy has been observed in many animal groups (see White, 1973), and snails are no exception. Our preliminary observations indicate that polyploid nuclei occur in ootestes (Babrakzai and Miller, 1975), albumin glands, salivary glands, giant neurons, and in developing embryos of land snails. Important aspects which should be pursued are cytophotometric analysis of various DNA classes within each tissue containing polyploid nuclei, and studies attempting to describe the role of polyploid nuclei in development of both embryos and adults.

Endometaphases can occasionally be seen in ootestes and in embryo squash preparations. In embryos endometaphases occur most often when they are about 1 mm in diameter. A simple count of the chromosome number is one way to determine the degree of ploidy in favorable preparations.

6. Studying Mitotic Metaphase Chromosomes without Treatment with Spindle Inhibitors:

The current "routine" procedure is to treat dividing cells with colchicine, colcemid, velban or some other spindle inhibitor. However, it is likely that important information is lost as a result of such treatment. This problem has been pointed out and discussed by Hsu (1976). Following Hsu's words of caution, we examined squash preparations of *Ashmunella* (Polygyridae) embryos which had not been treated with any inhibitor. Subsequently, we found chromosomal bridges in the anaphase cells of *A. ferrissii* and *A. chiricahuana*. This occurred in 2 embryos out of a total sample of 25 embryos from each species. The chromosomal bridges might be due either to dicentric chromosomes or to the "stickiness" of two chromosomes at submicroscopic levels.

In conclusion we would like to emphasize that the fields of molluscan cytology, cytotaxonomy and cytogenetics are wide open for the beginning experimental malacologist. There are now many

excellent techniques available for the identification of homologous chromosomes and the description of karyotypes. Their value in systematic problems, phylogenetic considerations and in describing the evolution of closely related species can not be over-emphasized. There exist many reports in the literature on chromosome numbers of molluscs, and these can now be supplemented by complete karyotype descriptions for these species. In the final analysis this would help to shed more light on the interrelationships within molluscan taxa at all levels.

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CURRENT TRENDS IN MALACOLOGY: ENVIRONMENTAL IMPACT STUDIES AND ENDANGERED SPECIES RESEARCH

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and

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Within the past ten years, two major pieces of Federal legislation have brought Washington bureaucratic alphabetese into the field of malacology, and have brought the science of malacology to the attention of many engineers, policy-makers, and even a number of biologists who had never before had contact with this field of study.

The first of these pieces of legislation is the National Environmental Policy Act of 1969, more familiarly known as NEPA. If Congress and the courts continue to uphold this landmark piece of legislation, it could well have as great an impact on this country's next two centuries as the Declaration of Independence and the Bill of Rights have had on the first two centuries.

In passing this act, Congress recognized the profound impact of man's activity on the interrelationships of all components of the natural environment. In Title I of NEPA, the Congress declared that it is the continuing policy and responsibility of the Federal Government to use all practicable means to improve and coordinate Federal plans and programs so that the Nation may—

(1) fulfill the responsibilities of each

generation as trustee of the environment for succeeding generations;

(2) assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings;

(3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;

(4) preserve important historic, cultural, and natural aspects of our natural heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice;

(5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and

(6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

At the heart of NEPA is the crucial Section 102 (2) C, which requires that all agencies of the

Federal Government shall "include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official [i.e., the official representative of the agency that is planning the project] on—

- (i) the environmental impact of the proposed action,
- (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
- (iii) alternatives to the proposed action,
- (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
- (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."

This detailed statement has become popularly known as an Environmental Impact Statement, or an EIS. Every time any Federal agency proposes to undertake any action which may have a significant effect on the environment, that agency is required by law to prepare an EIS on the proposed action. Copies of the EIS must be made available to Federal, State, and local environmental agencies, the President, the Council on Environmental Quality, and also to the public. It must accompany the proposal through the existing agency review processes.

At first, NEPA's Environmental Impact Statement requirements caught Federal agencies unprepared. Highway departments, the Corps of Engineers, and other agencies were largely staffed with engineers and designers who had been trained to solve problems in mechanics, design, and construction, but who had little or no familiarity with ecology or the life sciences. This situation is just beginning to change.

The first efforts of Federal agencies to comply with NEPA's EIS requirements were almost entirely directed toward the proposed projects' effects on recreational facilities, commercial and game species of fish, mammals, and birds—the traditional concerns of most state departments of natural resources or conservation. Non-game species and ecosystem diversity were rarely even

mentioned, and their importance to man was little understood or appreciated.

However, the preparation of EIS's did one thing more than require additional agency rubber stamps on project proposals. It gave the public an opportunity to become involved in the governmental decision-making process. Conservation organizations which for years had fumed over inept bureaucratic decisions to destroy natural areas while creating public works projects, landowners whose property was to be condemned, community groups whose neighborhoods were to be sacrificed, and even a very few concerned biologists began to read environmental impact statements and to ask some very searching questions about them.

In a number of cases citizens' groups opposing Federal projects found the agencies' environmental impact statements highly inadequate or misleading. When the agencies refused to change the EIS's, some of the citizens' groups decided to sue the Federal agencies involved in order to force a more realistic evaluation of the impact of the proposed projects. In some such cases, such as the Environmental Defense Fund's suit against the U.S. Army Corps of Engineers over the Cossatot Dam, the courts ruled the EIS was inadequate, and sent the agencies back to get more data. However, when the agencies returned with voluminous documents weighing many pounds, the courts generally weighed the evidence and decided that the impacts of the projects had been adequately described, so the projects could then go ahead.

There is no provision in NEPA which requires a project to be abandoned or modified no matter how adverse its impact may be, so long as the impact is adequately described in the environmental impact statement.

One of the first NEPA cases in which malacology played a role was the Environmental Defense Fund's suit against the U.S. Army Corps of Engineers over the proposed Tennessee-Tombigbee Waterway, a canal project which would channelize the Tombigbee River in Alabama, linking it with the Tennessee River, by excavating more earth than was moved during the building of the Panama Canal. Evidence was presented indicating that five endemic species of Unionidae in the Tombigbee River system would probably become extinct as a result of this project. Other evidence showed that the 253-mile canal

project would seriously disrupt the area's balance of nature and would damage wildlife and recreation along the river. However, this evidence was not enough to enjoin the Corps from building the canal, according to the Federal Court judge, who ruled in the Corps' favor.

In another early NEPA case the Environmental Defense Fund took the Tennessee Valley Authority to court over the issue of two high dams to be built at Normandy and Columbia on the Duck River, the largest and one of the most biologically diverse undammed streams remaining in the Tennessee River system. The possible extinction of native species of unionids and river snails was an issue in this case, and again EDF lost the case and the appeal. Normandy Dam was closed and began impounding water in May this year. Columbia Dam is now under construction, with approximately 10% of the project completed now.

While all of this was going on, a quiet but growing concern for the world's vanishing species was beginning to arouse public attention. The American Malacological Union was one of the first scientific organizations to call attention to this situation, holding a formal symposium on rare and endangered mollusks of North America at its 1968 annual meeting at Corpus Christi, Texas.

The formal involvement of the Federal government in endangered species conservation began with the Endangered Species Preservation Act of 1966. This act required the Secretary of Interior to judge what native species of wildlife were threatened with extinction, and to publish lists of them in the Federal Register. It also authorized him to conduct research on such animals and to use limited amounts of money from the Land and Water Conservation Fund to acquire habitat for these species.

In 1969 a new Endangered Species Conservation Act amended the first act and broadened its coverage to include all vertebrates, mollusks, and crustaceans. Endangered subspecies as well as species were recognized. The new act authorized the acquisition of water as well as land habitat for endangered species, increased the amount of money available for habitat acquisition to \$2.5 million per area and \$5 million per year, and provided significant authority for the conservation of endangered foreign wildlife.

Later the laws were again amended by the passage of the Endangered Species Act of 1973, which states: "The purposes of this Act are to

provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve [these] purposes." The act also states, "It is further declared to be the policy of Congress that all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of this Act."

This act extends the scope of Federal coverage to species within the entire plant kingdom, and to the whole animal kingdom, with the sole exception of "a species of the Class Insecta determined by the Secretary [of Interior] to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man." Not only species and subspecies, but also isolated and disjunct populations may be listed.

The present law requires the Secretary to publish in the Federal Register lists of all species determined to be either threatened or endangered. These species must be listed by both a scientific name and a common name—a problem for malacologists, since so few molluscan species have common names.

The term "endangered species" means any species which is in danger of extinction throughout all or a significant portion of its range. A "threatened species" is any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. The difference between the two categories is essentially one of priority of action.

The Secretary may also treat as endangered certain other species which look so much like the listed ones that enforcement personnel would have difficulty in differentiating between them and the listed species. This provision may well prove important in malacology, especially since few law enforcement people have been trained in molluscan taxonomy. The education of these people may well be an important task of malacologists in the future.

Criteria used by governmental officials to determine whether a species should be listed as endangered or threatened include:

- (1) the present or threatened destruction, modification, or curtailment of its

- habitat or range;
- (2) overutilization for commercial, sporting, scientific, or educational purposes;
- (3) disease or predation;
- (4) the inadequacy of existing regulatory mechanisms; or
- (5) other natural or manmade factors affecting its continued existence.

Under Section 5 of the present Endangered Species Act, the Secretary of Interior is directed to establish and implement a program to use all methods and procedures which are necessary in order to bring any endangered or threatened species to the point at which such measures are no longer necessary. "Such methods and procedures include, but are not limited to, all activities associated with scientific resources management such as research, census, law enforcement, habitat acquisition and maintenance, propagation, live trapping, and transplantation...."

Under the terms of this act, the U.S. Office of Endangered Species has thus far issued 12 research contracts to researchers in molluscan systematics and zoogeography. The first priority has been to find out what taxa are known to be threatened with extinction, to determine where these taxa now occur, and to learn what is happening or is about to happen to them. A status report must be prepared for each species to answer three basic questions: What is it? Where is it? Why is it in trouble?

Since many of the mollusk species which are potential candidates for listing are highly restricted in distribution and not all are well known, even to malacologists, the investigations supported by these research contracts are providing new information which is aiding in the solution of many taxonomic and zoogeographic problems that otherwise might not even have been tackled until the species was extinct.

As a serendipitous by-product of the field work done under these contracts, malacologists are obtaining new data on distribution and abundance not only for potentially endangered species, but also for many relatively common, widespread taxa. Field studies such as are sponsored by endangered species research contracts are providing valuable base-line data on faunal changes in different regions, which can then be correlated with various environmental modifications. Well-documented specimens taken during

these field surveys and deposited in museum research collections can be used to help solve taxonomic and zoogeographic problems, as well as serving as irrefutable evidence of the survival of the taxon at the time and place of collection. Exact localities and dates of collection are becoming increasingly essential on specimen labels because of the need to carefully document faunal changes in response to environmental alterations.

Attempts to delineate the ranges of endangered species sometimes bring to light new malacological problems which challenge the investigators. As an example, Grimm's studies of endangered land snails brought to light evidence that some land snail species tend to hybridize in disturbed habitat areas between formerly separate ranges, a phenomenon which has also been observed in certain species groups of plants.

A number of studies of the introduced Asiatic freshwater clam *Corbicula* have suggested that this bivalve invades disturbed habitats more readily than unmodified natural streams. It has been hypothesized that maintenance and restoration of natural conditions may be one of the most effective defenses against domination of the benthos by this exotic bivalve.

As endangered species are recognized and identified, it is expected that the research emphasis will gradually shift toward studies of the interrelationships of the various taxa with the many factors comprising their environments. Studies such as Vail's investigations of the survival of *Triodopsis albolabris* in an annually burned woodland, Mackie's investigations of the effects of various environmental factors on sphaeriid natality, and comparative ecological studies of several species occupying similar but not identical niches, such as the investigations reported by Hoagland, Davis, and Cain (all presented at the 1976 AMU meeting) will be needed to determine the particular factors in the environment which are limiting to the endangered species, and which factors must be maintained or modified in order to promote the survival and reproduction of the species.

Studies of the distribution of rare species frequently show that the ranges of two or more endangered or threatened taxa coincide or overlap. In such cases, protection of the natural integrity of a single habitat area can result in protecting more than one endangered species, as

well as the biotic community of which these species are integral components. As an example, the ranges of the endangered Morro Bay Kangaroo Rat and the Banded Dune Snail, *Helminthoglypta walkeriana*, now proposed as an endangered species, coincide. In Ohio, the Big Darby Creek ecosystem which supports the only known population of the Scioto Madtom, a Federal endangered fish species, also supports at least seven additional fish species and four unionid mollusk species on the official state list of endangered wild animals. In the Tennessee River basin, the undammed portions of the Clinch, Powell, Nolichucky, and Duck Rivers each support unique assemblages of endemic bivalve, gastropod, and fish species, many of which have either been listed or are in the process of being listed.

The ecosystem approach toward endangered species restoration is clearly mandated. By acquiring and protecting the critical habitats for such species, additional plant and animal taxa native to these habitats but not now recognized as endangered may well be protected as a kind of by-product. In addition, forms occurring in these areas which are not now endangered can be given living-space which may prevent them from becoming endangered in the future. The study of these natural ecosystems and their functions may well provide new insights by which man can better utilize the resources of his agricultural ecosystems.

Few molluscan taxa are so large and spectacular that zoos feel a need to maintain and propagate them. Few of them are so well-studied that the necessary conditions for survival and reproduction are known. Preservation of captive populations of animals in aquaria, terraria, and gardens; introductions outside the native range; and artificial mass production programs have proven chancy and subject to the fickleness of the budgetary process—especially during times of war or energy crisis. In the long run, the genetics of a captive population may change, variability is lost, and behavior patterns adaptive to survival in the wild may disappear. Introductions of endangered species into new habitats may either fail or be hazardous to the native species already occupying those habitats.

One of the most important parts of the Endangered Species Act of 1973 is Section 7, which reads:

The Secretary shall review other

programs administered by him and utilize such programs in furtherance of the purposes of this Act. All other Federal departments and agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species...and by taking such action necessary to insure that actions authorized, funded, or carried out by them do not jeopardize the continued existence of such endangered species and threatened species or result in the destruction or modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with the affected States, to be critical.

Although there is no requirement in the National Environmental Policy Act which requires Federal agencies to do anything beyond writing an environmental impact statement, Section 7 of the Endangered Species Act clearly directs these agencies to take such action as is necessary to insure that their activities do not further jeopardize the continued existence of listed species.

Twenty-five mollusk species have now been officially listed as endangered, and 37 others have been listed in the Federal Register as proposed endangered species. This is still far short of the 250 mammal species and 209 bird species now listed as endangered, or the more than 1,700 plant species currently proposed for listing (8% of the seed plants and ferns in the nation!) However, over 400 additional molluscan species are currently under 'consideration and may be proposed when there is sufficient data available on their status.

Federal agencies now will be required to include information about the probable impact of their proposed projects in each EIS. The inclusion of endangered mollusks on the Federal list may provide new ammunition for the Environmental Defense Fund and other citizens' groups in court trials on controversial public works projects.

Just last month the U.S. Soil Conservation Service held a preliminary hearing on their proposal to channelize the Paint Rock River in Alabama. AMU member Dr. Paul Yokley and

biologist Bruce Bell of the U.S. Fish & Wildlife Service's Decatur office, using data from past malacological literature and from recent Ohio State University Museum of Zoology records, informed the SCS that four endangered unionid species occur in the Paint Rock River. Consequently, the SCS will now contact the Department of Interior to determine what action must be taken, under the terms of the Endangered Species Act, to prevent further jeopardization of the continued existence of these species.

Research into new technologies of flood damage reduction, water supply, erosion control, and waste management is needed in order to provide better alternatives to the costly public works engineering projects we have been using. By utilizing ecological approaches to the solution of such problems, we may find cheaper and more efficient ways of utilizing natural processes to

convert "wastes" to resources. Perhaps we may find ways to utilize various molluscan species in solving these problems. Bivalve mollusks, for example, have been suggested as living monitors of water quality in streams. Some of them may one day be employed as living filters to process organically enriched wastewaters into usable proteins.

The preservation of the genetic variability which will make such developments possible in the future depends largely on how effectively NEPA and the Endangered Species Act are used to protect this resource. The Phylum Mollusca constitutes a major segment of Earth's animal life. Malacologists of today face a major challenge and obligation to make a real contribution both in research and in educating the agencies, the courts, and the citizens of the planet about the importance of preserving natural ecosystems and genetic diversity of living forms.

AMU ANNUAL REPORTS

AMU ANNUAL BUSINESS MEETING, AUG. 2-6, 1976 COLUMBUS, OHIO

The business meeting of the Forty-Second annual session of the American Malacological Union was called to order at 3:30 p.m. in Hitchcock Hall, Ohio State University, on Aug. 5, 1976, by President Dorothea Franzen.

Registration was announced as 129 for this annual meeting.

Minutes of the Forty-First meeting held in San Diego, California, as printed in the 1975 Bulletin, were APPROVED.

President Franzen read the report from Corresponding Secretary Paul Jennewein in his absence. APPROVED. (Printed below).

The Publications Report from Editor Dee Dundee was summarized by Dr. Franzen and included the following pertinent statistics: \$4200.00 was budgeted for 1975 for the Bulletin. The joint Bulletin cost \$4399.24 but the Western Society of Malacologists paid \$1101.00, leaving a cost to AMU of \$3298.24. This was \$901.76 under budget. The Fall and Spring Newsletters were sent at a total of \$613.00, or \$387 under budget. Total postage for editorial activities was \$228.02.

Newsletter Editor Dorothy Beetle's report to Council was reported to members, noting that the Newsletters are now being printed and mailed in New Orleans, La., on AMU's postal permit, resulting in savings.

Council approved a motion to proceed with publication of the INDEX of AMU Bulletins prepared by honorary member Margaret Teskey. AMU members are urged to buy and help publicize this Index. The price is \$6.50, and orders are accepted with payment in U.S. funds to Treasurer Myra L. Taylor.

Morris Jacobson reported on *How to Study and Collect Shells* to Council and requested help in securing permanent storage for copies now being housed at a member's home in New York City. Council's acceptance of the offer from Dr. Tucker Abbott to help promote sales of this publication the next year was announced to members.

All reports from the Publications Committee were APPROVED.

Treasurer Myra L. Taylor gave her report, as audited by a committee chaired by Dr. T. E. Pulley. APPROVED (Printed below).

Dr. Franzen reported that in further action Council had accepted a report from the Treasurer on finances of the joint meeting at San Diego in 1975.

Dr. Harald Rehder presented the 1977 budget. APPROVED as follows:

Receipts:

Memberships	\$5,000
Sales HSCS	600
Back Issues, Other Pub.	500
Page Charges	1,200
Misc. (Inc. donations)	100
Meeting surplus	300

\$7,700

Expenditures:

Printing of Bulletin	\$4,500
Newsletters	800
Printing Miscellaneous	300
Postage	700
Office Supplies, misc.	200
Travel, Sects., Treas.	800
Expenses, Pres., V.-Pres.	150
Editor	50
Filing Fee	5
Conservation	100
Miscellaneous	95

\$7,700

The Constitutional Amendment approved by Council was submitted as follows: Article III. Section 2.c of the AMU Bylaws: "The Vice-President shall assist the President on request, shall serve as Membership Chairman, and shall serve as Chairman of the Annual Meeting Site Committee with the responsibility of arranging for and announcing the site of the Annual Meeting that will be held when the now Vice-President will be President of AMU." APPROVED.

The History and Archives report from Dr. William Clench, chairman, was read by Dr. Franzen. Additions are being made to the Archives housed at the Delaware Museum of Natural Science. An important collection of slides from meetings and members will be preserved with identifications. Over 500 letters, with a host of important signatures, of Mrs. Imogene Robertson, former AMU secretary, have been received for Archives from the Buffalo Museum. APPROVED.

Dr. Franzen read a letter from Dr. Henry Russell tendering his resignation from the Vice-Presidency in 1976 and announced that he had continued to function as membership chairman, completing business to send 45 clubs and 27 domestic and 11 foreign institutions invitation letters. APPROVED.

Dr. Franzen read the Nominating Committee report, prepared by Dr. Harold Murray, chairman, Dr. Donald Moore and Dr. William Emerson. APPROVED BY ACCLAMATION as follows:

President: Dr. George Davis (one year term)
President-Elect: Dr. Carol Stein (one year term)
Vice-President: Mr. William Old (one year term)
Recording Sect.: Mrs. Constance Boone (three year term)
Councillors-at-large: Dr. Richard S. Houbriek (two year term) Mr. Herb Athearn (two year term)

Motions brought to Council from the Conservation Committee and there approved were presented as follows:

MOTION by Dr. Harold Murray, seconded by Dr. Tucker Abbott, that AMU go on record supporting continued litigation of the City of Columbus vs. the Ohio Department of Natural Resources on Big Darby Creek, and to draw from the treasury up to \$50.00 to continue to employ Sigreti and Tousey as attorneys. APPROVED.

MOTION by Dr. Carol Stein and seconded by Dr. Murray that Dr. Franzen as president of AMU write a letter to the director of the Ohio Department of Natural Resources to take all possible steps to protect Big Darby Creek as a natural

ecosystem and to declare it a State Scenic River. APPROVED.

It was suggested that local (Columbus) people investigate the nomination of Big Darby Creek as a National Wild and Scenic River, pursuant to the National Scenic River Act of 1967. This should be done through the local U.S. Senators and Representatives, if sympathetic.

MOTION made by Dr. George Davis and seconded by the president to the chairman of the Ad Hoc Committee on the Canaveral Wilderness Area of the Canaveral National Seashore Park. APPROVED.

It was suggested that the local (Brevard Co., FLA) Astronaut Trail Shell Club be urged to offer support of this motion.

MOTION made by Leslie Hubricht and seconded by Alice Imlay that Dr. Franzen as president of AMU write a letter to Senator Jennings Randolph, chairman of the Senate Committee on Public Works, and to Senator Edmund Muskie, an influential member of the Committee, informing them that AMU supports Section 404 of the Federal Water Pollution Act of 1972, as interpreted by the Courts since March, 1976. APPROVED.

Motion made by Marian Havlik and seconded by Lloyd Pratt that AMU incoming president Dr. George Davis request Nathaniel P. Reed, Assistant Secretary of the Department of the Interior, to list the Naiads on the Tennessee-Tombigbee Project which will become endangered or extinct as a result of the project. (List of Naiades to be provided by Dr. David Stansberry). APPROVED.

MOTION made by Frieda Schilling and seconded by Hessie Kemper that AMU incoming President Dr. George Davis request Nathaniel P. Reed, Assistant Secretary of the Department of the Interior, pursuant to Section 4-c-2 of the Endangered Species Act of 1973, to list the Naiades on the Meramec Dam Project which will become endangered or extinct as a result of the Project. (List of Naiades to be provided by Dr. David Stansberry). APPROVED.

MOTION made by Marian Havlik and

seconded by HESSIE KEMPER that AMU incoming president Dr. George Davis write the U.S. Attorney General Edward Levi requesting action on the knowing violation of Section 7 of the Endangered Species Act of 1973 by the Corps of Engineers, St. Paul District, by dredging in areas of endangered *Lampsilis higginsii* in the Upper Mississippi River. It is urged that a survey of populations and habitats be made. Copies of this letter are to be sent to the Senators of Minnesota, Wisconsin, and Iowa.

Motion amended to include letters to the Governors of the three states.

MOTION APPROVED.

A motion brought to Council requesting an amendment to the Bylaws formally establishing the Conservation Committee and defining the duties of the chairman was returned to the committee by Council with the recommendation that the committee chairman bring to next year's meeting of Council a plan devised in cooperation with incoming president Dr. Davis to streamline business by the committee.

A motion brought to Council from the Conservation Committee that AMU enter into the matter of the Duck River, Tennessee, Project through the filing of Amicus Curiae brief to the court concerned was amended on advice of Legal Counsel Wallace Roberts to be entered into through sending of a letter by incoming president Dr. George Davis to the proper judge. APPROVED.

A motion was approved that actions voted in conservation motions as outlined above will be carried out when the conservation chairman supplies complete names, addresses and materials to Dr. Franzen and Dr. Davis.

It was announced by Dr. Franzen that Council

had approved the solicitation of donations from members at this meeting to continue legal fees in the Big Darby Creek matter. APPROVED.

Council's action of approving the invitation from the Naples Shell Club to hold the 1977 annual meeting at Naples, Florida, the second week of July was announced by Dr. Franzen and APPROVED by members.

A motion had been approved in Council to host a joint meeting with the Western Society of Malacologists in 1979 or 1980 on the East Coast. This met APPROVAL and was amended to include Texas in consideration for site.

Dr. Franzen explained that a general discussion was held at Council on allowing commercial sales and exhibits of shells or other items at annual meetings. A motion to allow such sales and exhibits was defeated in Council. After some clarification and discussion on intent, a motion was APPROVED by members forbidding commercial sales and exhibits at official meeting sessions and activities.

Council approved a motion stating that the AMU member who serves as legal counsel be named as an ex-officio member of the Executive Council. APPROVED by members. Wallace Roberts serves in this capacity at present.

Dr. Franzen made a report on the Literature Auction and Book Bazaar held the evening before and thanked everyone involved for this successful first event for AMU. \$971.00 was announced as the gross sales and auction. (It is further here reported to members that the net profit to AMU is now reported as \$983.53.) All materials had been donated by members for sale and auction.

With no other business brought before the meeting, ADJOURNMENT took place at 4:30 p.m.

Respectfully submitted,
Constance E. Boone,
Recording Secretary

REPORT OF THE TREASURER FOR THE FISCAL YEAR ENDING DECEMBER 31, 1975.

CHECK BOOK BALANCE, JANUARY 1, 1975

RECEIPTS:

Memberships: Regular	2578.11	
Life	393.00	
Corresponding	123.88	
Clubs & Institutions	<u>685.50</u>	3780.49
Sales: How To Study & Collect Shells	1301.49	
Rare & Endangered Species	7.78	
Bulletin, Back Issues	170.75	
Teskey Index To Bulletins	27.50	
Bulletin Reprints	<u>137.00</u>	1644.52
Page Charges To Authors	1270.00	
Contributions to Legal Defense Fund	15.00	
Donations (form on Dues Notices)	71.25	
Miscellaneous Receipts	<u>49.00</u>	1405.25
Total Receipts From Activities		6830.26
Transferred From Savings Account		<u>2111.88</u>
		<u>8942.14</u>
TOTAL CASH ACCOUNTED FOR:		9885.50

DISBURSEMENTS:

Bulletin-Printing, Postage, Etc.	4316.93	
Newsletters	436.13	
Conservation Committee	86.59	
Membership Committee	30.89	
President's Operating Fund	55.56	
California Filing Fee	5.00	
Officers Expenses to Meeting (3)	857.61	
Legal Defense Expenses	9.44	
How To Study & Collect Shells Expenses	32.86	
Other Postage	370.72	
Other Printing	295.37	
Office Supplies	148.44	
Miscellaneous Expenses	<u>109.25</u>	6754.79
Total Disbursements		6754.79

CHECK BOOK BALANCE, DECEMBER 31, 1975

3130.71

TOTAL CASH ACCOUNTED FOR:

9885.50

Savings Acct. #2-6621, 1st Federal Savings	407.83	
Interest added, less withdrawal *	10.39	-408.22
Balance on hand, 12/31/75		10.00
Balance on hand, 12/31/75		
Savings Cert. #60-3332-02, 1st. Federal Savings	3383.72	
Interest added, Balance on 12/31/75	236.27	3619.99

Loan on Savings Cert. for Bulletin at $8\frac{1}{4}\%$ * 1703.66

*See Treasurer's Note on previous page.

RECAPITULATION OF ASSETS, DECEMBER 31, 1975

Cash in checking account, Broadway National Bank	3130.71
Treasurer's Petty Cash, Myra Taylor	25.00
Secretary's Petty Cash, Constance Boone	75.00
Savings Account #2-6621, 1st Federal Savings & Loan	10.00
Certificate of Deposit #60-332-02, 1st Federal Savings & Loan	3619.99
Loan #9600055 of \$1703.66, at $8\frac{1}{4}\%$ interest	-1844.21
Net value of CD	<u>1775.78</u>

TOTAL ASSETS: 5016.49

ALLOCATED TO LIFE MEMBERSHIP FUND: 1988.88

A.M.U. NET WORTH - DECEMBER 31, 1975 3027.61

CHANGES IN CAPITAL ACCOUNT:

A.M.U. CAPITAL ACCOUNT, JANUARY 1, 1975 3239.03

A.M.U. CAPITAL ACCOUNT, DECEMBER 31, 1975 3027.61

NET DECREASE IN ASSETS IN 1975 211.42

Respectfully submitted,

Myra L. Taylor, *Treasurer*

REPORT FROM THE RECORDING SECRETARY

Memberships for 1975, reviewed in January, 1976, were as follows:

Honorary Life President	1
Honorary Life Members	6
Regular Memberships	
(All Western Hemisphere)	560
Additional Family Members	111
Corresponding Members	15
Affiliated Memberships:	
(Institutions)	
Domestic	33
Foreign	12
Clubs, regional organizations	47
Life members	<u>27</u>
<i>Total</i>	812
Subscriptions for Bulletin	4

dropped for nonpayment, and there were 5 deaths. Five members were reinstated in 1975.

This shows that we enrolled 109 new and reinstated members and institutional affiliates in 1975.

As of July, 1976, records indicate 65 new members, two new affiliate institutional members, four new foreign correspondents, one reinstatement of a foreign affiliate institution, and two new subscribing institutions for the current year. There has been one new life member completed. One death has been reported to me, and we show four resignations. The final request for dues to be sent by the treasurer should bring in more payments of dues from the 200 members not yet paid and from the 20 shell clubs not yet in the 1976 tally. A complete count to show the result of the raise in dues voted in 1975 will not be available until the end of the fiscal year.

In 1975 ads were placed in several publications, the membership chairman sent out many letters inviting membership, and we were given the special offer of a bonus to new members of copies of *American Malacologists* and the 1975 *Supplement*. All this added to help us secure new members and continues this year.

This is an increase in several categories from 1974, with a total increase of 17 memberships and four continuing subscribers. Total for 1974 was 785, with no subscribers for Bulletin only.

My records indicate four resignations in 1975, 68 unpaid regular and family memberships, two corresponding memberships unpaid, 3 shell clubs

A letter from Dr. R. Tucker Abbott has been put in the file indicating his gift of AM and Supplement to new members through Dec. 31, 1975, totalled 29 copies of hardback editions, 7 copies of paperbacks of AM, and 36 copies of the Supplement. This amounted to the substantial gift of \$470.89. A letter of acknowledgement from AMU has been sent to Dr. Abbott.

The usual business of writing welcoming letters and mailing membership cards to new members, answering inquiries for old Bulletins and invoicing and mailing orders, mailing copies of ordered *Rare and Endangered Species Symposium* continues at an increased rate. There is continual updating of addresses and titles of

members. Appeals for help through the Newsletters have brought some results. It is noted that the Spring Newsletter had 12 returns of changes of addresses. Postage costs continue to rise.

Mail stickers are being Xeroxed now and can be updated for each mailing. Members can be of considerable help if they understand that these labels are made up a month or so before mailing and that the slightest change of address causes the post office to return or destroy mail sent out on a bulk permit.

Respectfully submitted,

Constance E. Boone

REPORT OF THE CORRESPONDING SECRETARY FOR THE YEAR UP TO 10 JULY 1976

Loss of the forwarding arrangement in July 1975 with the postmaster at Marinette, Wisconsin, after about five years, reduced the volume of mail to a trickle. The Superintendent of Mails in Marinette wrote to say that regulations required forwarding of mail for only one year, but that the Marinette Post Office had "continued to forward the mail, thinking it would soon dwindle off and there would be none to forward. Forwarding addresses are not renewable so the mail is being sent back to the addressee indicating 'No forwarding address on file,'" the superintendent wrote. I replied, pointing out that the Marinette address was contained in several publications which are of world-wide popularity and still being printed. If the Postal Service were really interested in "service," as the Postmaster General had been emphasizing in speeches around the country and to Congress, I continued, it would forward the letters to an organization interested in replying to such mail and thereby render individual service. I pointed out that the cost of sending a letter on to the intended recipient was about as much as sending it back to the original sender, marked with a falsehood. This logic, however, didn't seem to carry much weight in view of national attempts to cut costs of mail processing, regardless of how much it affects service. Apart from my battle with bureaucracy, the drop in the volume of mail was probably beneficial to the AMU and was why I didn't pursue the issue with higher federal officials. Ninety per cent of the loss was in the mail from youngsters, whose curiosity once satisfied, might not linger into college and encourage further study of malacolo-

gy for quite a while. From about 35 letters a month, the rate dropped to about a dozen. The majority of these involved questions on membership or where they could obtain "How to Study and Collect Shells" or other publications on malacology. The loss of mail from children certainly reduced our postage costs, and, with the rising first class rates, has helped to strengthen our financial condition.

The generous offer of Dr. R. Tucker Abbott to carry an advertisement in THE NAUTILUS, encouraging membership in the AMU, was welcomed, and, I'm sure, added to the organization's membership. A copy of that ad was also carried without charge by Tom Rice in the quarterly, OF SEA AND SHORE. (A copy of the ad was sent to Jean M. Cate, associate editor of the VELIGER, but wasn't used because of the publication's policy never to run advertising copy.) Reprints of the ad were also ordered and are being distributed when there are inquiries on membership.

Another source of membership — and sales of the AMU booklet — was the article which appeared early in December 1975 in the New York Times' metropolitan edition on shell collecting. It gave the address of the corresponding secretary as a place where additional information might be obtained.

Altogether, about 245 copies of the booklets have been sold during the past year.

Respectfully submitted,

Paul R. Jennewein

THE AMERICAN MALACOLOGICAL UNION, INC. ACTIVE MEMBERS 1976

Membership List Revised October 10, 1976

- Abbott, Dr. R. Tucker, Delaware Museum of Natural History, Box 3937, Greenville, DE. 19807.
- Abreau, Mrs. Vivian B., 2709 Dewey St., Tampa FL. 33607 (Sea life relationship to human race).
- Aguayo, Dr. Carlos G., Dept. of Biology, Univ. of Puerto Rico, Mayaguez, Puerto Rico 00708.
- Ahlstedt, Steven, 34 East Norris Rd., Norris, TN. 37828 (Biological Aide in Fisheries, TVA).
- Albert, Mr. and Mrs. Ernest, 905 S. Bayshore, Safety Harbor, FL. 33572.
- Alexander, Robert C., 423 Warwick Rd., Wynnewood, PA. 19096.
- Allen, James E., 1108 Southampton Dr., Alexandria, LA. 71301 (Tertiary micro-mollusca).
- Allen, Dr. J. Frances, 7507 23rd Ave., Hyattsville, MD. 20783.
- Allen, Mrs. Lawrence K., Box 822, Port Isabel, TX. 78578 (*Murex*, *Pecten*, world marines; dealer).
- Allen, Miss Letha S., 187 Argyle St., Yarmouth, Nova Scotia, Canada B5A 3X2 (General).
- Anders, Kirk W., Shells of the Seas, Inc., P.O. Box 1418, Ft. Lauderdale, FL. 33302 (Volutidae, all rare shells).
- Anderson, Carleton Jay Jr., 56 Kettle Creek Rd., Weston, CT. 06880.
- Anderson, Richard V., Dept. of Biological Scs., Northern ILL. Univ., DeKalb, IL. 60115 (Freshwater Pelecypods).
- Andrews, Dr. Jean, 241 Melrose, Corpus Christi, TX. 78404.
- Angstadt, Mrs. Earle K., 247 Penn St., Reading, PA. 19602.
- Armington, Mr. and Mrs. Stewart F. Jr., 15932 Brewster Rd., Cleveland, OH. 44112 (*Cypraea* of Australia).
- Arnold, Charles E., 3206 Floyd Ave., Richmond, VA. 23221 (Collecting, photographing).
- Aslakson, Capt. Carl I., 5707 Wilson Lane, Bethesda MD. 20034.
- Atheart, Mr. and Mrs. Herbert D., Museum of Fluvial Mollusks, Rt. 5, Box 499, Cleveland, TN. 37311 (Freshwater mollusks).
- Atheart, Mrs. Roy C., 5105 N. Main St., Fall River, MA. 02720 (Land shells).
- Avellanet, Mrs. Helene, 105 Clipper Way, Fair Winds Villas, Nokomis, FL. 33555.
- Avery, Mrs. R. Gail, Box 2557, Harbor OR. 97415 (West American mollusks; exchange).
- Babrazkai, Mr. Noorullah, Dept. General Biology, Univ. of Arizona, Tucson, AZ. 85721.
- Baerreis, David A., Dept. of Anthropology, 5240 Social Science Bldg., Madison, WI. 53706 (Paleoecological interpretation through mollusks).
- Bagdon, Mr. and Mrs. Anthony, 440 Home Dr., Trafford, PA. 15085.
- Baily, Dr. Joshua L. Jr., 4435 Ampudia St., San Diego, CA. 92103.
- Baker, Mrs. Horace B., 11 Chelton Rd., Havertown, PA. 19083.
- Baker, John A., 147 Hedgegrove Ave. Satellite Beach, FLA. 32937 (General).
- Banek, Thomas J., c/o L. Shaw, 311 Vassar Ave., Swarthmore, PA. 19081 (Marine gastropods, taxonomy, ecology).
- Barker, C. Austin, 2 Hickory Dr., Rye, NY. 10580.
- Barlow, Mrs. G. Barton, 5 Downey Dr., Tenafly, NJ. 07670.
- Barnett, Mr. and Mrs. George H., Koran Ave., MD. #23, Newburgh, NY. 12550.
- Barr, John W. Jr., 200 26th St., N.W., Apt. C 214, Atlanta, GA. 30309 (*Cypraeidae*).
- Barton, Mrs. James, 200 Newfield Dr., Rochester, NY. 14616 (*Cypraea*; worldwide general, esp. Hawaiian).
- Bateman, William J., 15 Fairlawn St., Lowell, MA. 01851 [*Cypraea*, *Volutes*].
- Bates, Dr. John M., 1900 Dexter Ave., Ann Arbor, MI. 48103.
- Bauchman, Frank A., 1601 Big Bethel Rd., Hampton, VA. 23666 (Collecting).
- Bauer, Mr. and Mrs. Hugo C., 2126 45th St., Galveston, TX. 77550 (all Mollusca).
- Baum, Newman N., 83 Weaving Lane, Wantagh L.I., NY. 11793.
- Baxa, Mrs. Dorothy, Box 177, Genesee Depot, WI. 53127.
- Bazata, Kenneth R., Nalco Environmental Sciences, 4010 Northwest 39th St., Lincoln, NE. 68524.
- Bearse, David T., Grad. School of Oceanography, Univ. of R.I., Kingston, RI 02881 (Shellfisheries).
- Beetle, Dorothy E., 375 W. Galbraith Rd. #42, Cincinnati, OH. 45215. (U.S. Land & F.W. Moll.).
- Bennett, Sally, 514 W. Rose Lane, Phoenix, AZ. 85013. (Panamic Province shells).
- Bequaert, Dr. Joseph C., Dept. of Entomology, Univ. of Arizona, Tucson, AZ. 85717.
- Bereza, Daniel J., 825 N. 24th St., Philadelphia, PA. 19130 (Unionidae; Pleuroceridae).
- Berman, Lynn, 8 Peter Cooper Rd., New York, NY. 10010 (Marine).
- Berke, Ian, 4032 23rd St., San Francisco, CA. 94114.
- Berry, Dr. and Mrs. Elmer G., 8506 Beech Tree Court, Bethesda, MD. 20034.
- Berry, Dr. S. Stillman, 1145 W. Highland Ave., Redlands, CA. 92373.
- Bianchi, Mrs. Ann, The Pink House Motel, Goodland, FL. 33933.
- Bickel, David, Dept. Earth Sciences, Minot State College, Minot, ND. 58701 (Systematics and ecology of freshwater mollusks, esp. Pleurocerids).

- Bijur, Jerome M., 135 Seventh Ave. N., Naples, FL 33940 (Buy, exchange Florida and Caribbean marine).
- Bing, Ruth Rosser, P.O. Box 2612, Muhlenburg Station, Plainfield, NJ 07060 (Art-Photography, oil painting).
- Bippus, Mr. and Mrs. Alvin C., 2743 Sagamore Rd., Toledo, OH 43606 (Marine gastropods).
- Blankenship, Shaw, Rt. #2, Crab Orchard, KY. 40419 (Freshwater mussels).
- Blaser, James, 1846 Laurel Lane, Amherst, OH. 44001 (Florida mollusks; Ohio freshwater mollusks).
- Bleakney, Dr. J. Sherman, Dept. of Biology, Acadia Univ., Wolfville, Nova Scotia, Canada BOP 1X0 Nudibranchs and sacoglossans; ecology, zoogeography, systematics).
- Bledsoe, William D., 352 Bon Hill Rd., Los Angeles, CA. 90049.
- Body, Ralph L., 2538 10th Ave. W., Seattle, WA. 98119.
- Bogan, Arthur E., Research Ass't., Zooarchaeology, Dept. of Anthropology, Univ. of Tenn., Knoxville, TN. 37916.
- Boone, Mr. and Mrs. Hollis Q., 3706 Rice Blvd., Houston, TX. 77005.
- Borror, Kathy Gail, OSU, Museum of Zoology, 1813 N. High St., Columbus OH. 43210.
- Boss, Dr. Kenneth J., Museum of Comparative Zoology, Harvard Univ., Cambridge, MA. 02138.
- Bottimer, L. J., Rt. 1, Box 205, Tow, TX. 78672 (recent and fossil mollusks).
- Boyd, Dr. and Mrs. Eugene S., 6806 Gillis Rd., Victor, NY. 14564 (Phylum Mollusca - all aspects).
- Branau, Mrs. Marc, 6827 Basilwood, San Antonio, TX. 78213.
- Brandyberry, John J., 6323 Middlebranch Ave., NE, North Canton, OH. 44721 (Marine mollusca).
- Branson, Dr. Branley A., P.O. Box 50, Eastern Kentucky Univ., Richmond, KY. 40475.
- Bratcher, Mrs. Twila, 8121 Mulholland Terrace, Hollywood, CA. 90046.
- Brean, Clark, 705 E. Sherman, Lebanon, OR. 97355 (Student, Cypraea).
- Bretsky, Sara S., 91 Upper Sheep Pasture Rd., East Setauket, NY. 11733 (Ecology and evolution of Bivalvia, Tertiary and Recent).
- Bricker, Mrs. Minnie, Miss Donna Bricker, R.D. 6, Box 476, Hanover, PA. 17331 (Conchs and Whelks).
- Britton, Joseph C. Dr., Dept. of Biology, Texas Christian Univ., Ft. Worth, TX. 76129.
- Brooks, Mr. and Mrs. John C., 3050 Sunrise Blvd., Ft. Pierce, FL. 33450.
- Brooks, Dr. and Mrs. James C. Jr., P.O. Box 490127, College Park, GA. 30349 (Cypraea, Murex).
- Brown, Dr. and Mrs. Harvey E. Jr., 9455 S.W. 81st Ave., Miami, FL. 33156.
- Broyles, Dr. and Mrs. Ralph E., 5701 Fairfield Ave., Ft. Wayne, IN. 46807.
- Brunson, Dr. Royal Bruce, Univ. of Montana, Missoula, MT. 59801.
- Bryant, John C., 200 Bryant Rd., Hillsboro, OH. 45133.
- Buckley, George D., 164 Renfrew St., Arlington, MA. 02174.
- Buehler, William, 113 16th Ave. East, Ashland, WI. 54806 (Freshwater mollusks).
- Buerk, Dr. Minerva S., Maybrook Chalet, 331 Penn Rd., Wynnewood, PA. 19096 (Anatomy, histology).
- Buffet, Miss Sydney, 233 Central #3, San Francisco, CA. 94117.
- Bullis, Harvey R. Jr., 121 Island Dr., Key Biscayne FL. 33149.
- Burch, John B. Dr., Museum of Zoology, University of Michigan, Ann Arbor, MI. 48104 (Land and fresh water mollusks).
- Burch, Mrs. John Q., 1300 Mayfield Rd., Apt. 61-L, Seal Beach, CA. 90740.
- Burch, Mrs. Thomas A., P.O. Box 309, Kailua, HI. 96734 (Dredging).
- Burger, Sybil B., 3700 Gen. Patch N.E., Albuquerque, NM 87111 (Gulf of Mexico; land snails).
- Burgers, Dr. and Mrs. J.M., 4622 Knox Rd., Apt. 7, College Park, MD. 20740.
- Burghardt, Mr. and Mrs. Glenn, 11424 Pioneer Ave., Oakdale, CA. 95361.
- Burky, Dr. Albert J., Dept. of Biology, Univ. of Dayton, Dayton, OH. 45409.
- Burr, Raymond, 7476 Hillside Ave., Los Angeles, CA. 90046.
- Cahill, Michael, 1509 NE 5 Ave., Ft. Lauderdale, FL. 33304.
- Campbell, Mrs. Minnie Lee, 3895 DuPont Circle, Jacksonville, FL. 32205 (General).
- Capo, Thomas R., 3875 Waldo Ave., Apt. 2 D, Bronx, NY. 10463 (Benthic ecology).
- Cardeza, R. Adm. and Mrs. Carlos M., P.O. Box 6746, Houston, TX. 77005; summer add.-1718 Jewel Box Dr., Sanibel, FL. 33957 (Florida and Texas shells).
- Cardin, MSGT. Charles, Box 3539, APO San Francisco, CA. 96328.
- Carlton, James T., Dept. of Geology, Univ. of California, Davis, CA. 95616 (Estuarine and brackish water mollusks).
- Carney, Dr. W. Patrick, Box 14, NAMRU-2 Taipei, APO San Francisco, CA. 96263.
- Carr, Mrs. Jack C., 912 Broadway, Normal, IL. 61761 (Exchange worldwide marine).
- Castagna, Michael, Va. Institute of Marine Science, Wachapreague, VA. 23480 (Pelecypod larval behavior).
- Cate, Mr. and Mrs. Crawford N., P.O. Drawer 710, Rancho Santa Fe, CA. 92067. (*Mitra*, *Cypraea*; no exchanges).
- Cetnar, Dr. and Mrs. Eugene J., 4379 Ramsgate Lane, W. Bloomfield, MI. 48013.
- Chace, Emery P., 24205 Eshelman Ave., Lomita, CA. 90717.
- Chandler, Carl B. and Doris M., P.O. Box 621, Chatham, MA. 02633 (Cones, *Cypraea*).
- Chadwick, Albert F., 2607 Turner Rd., Wilmington, DE. 19803 (Marine).
- Chamberlin, Ursula (Mrs. John), Mountain View Rd., Fishkill, NY. 12524 (Compiling collection N. Atl. marines).
- Chanley, Mr. and Mrs. Paul E., P.O. Box 645, New Suffolk NY. 11956.
- Chauvin, Daniel, 3950 Hollister #79, Houston, TX. 77055.
- Chichester, Lyle F., 31 Chamberlain St., New Britain, CT. 06052 (Ecology of terrestrial gastropods, biology of land slugs).
- Christensen, Carl C., Dept. of General Biology, Univ. of Arizona, Tucson, AZ. 85721.

- Christie, John D., Ph.D., The Rockefeller Foundation, 1133 Ave. of the Americas, N.Y., NY. 10036.
- Chrosiecowski, Przemyslaw K., Aptdo. 125, Maracay 3KO, Venezuela (Planorbidae).
- Clark, John W.Jr., Texas Historical Commission, P.O. Box 12276, Capitol Station, Austin, TX. 78711 (Economic exploitation of mollusks by prehistoric Indians).
- Clarke, Dr. Arthur H., Head Invertebrate Division National Museums of Canada, Ottawa, Ont., Canada K1A OM8.
- Clench, Dr. William J., 26 Rowena St., Dorchester, MA. 02124.
- Clover, Phillip W., P.O.Box 83, Glen Ellen, CA. 95442 (Rare *Cypraea*, *Conus*, *Voluta*, *Murex*, *Marginella*—Buy and exchange).
- Coan, Dr. Eugene V., 891 San Jude Ave., Palo Alto, CA. 94306.
- Cohen, Anne C. (Mrs. Daniel M.), Dept. of Invertebrate Zoology (W-118), Smithsonian Institution, Washington, DC. 20560 (*Loliginidae*; *Litiopa melanostoma*).
- Coleman, Dr. Richard W., Dept. of Biology, Upper Iowa College, Fayette, IA. 52142 (Environmental interrelationships, plants-invertebrates).
- Compitello, Mrs. Juliette, 5630 Alta Vista Rd., Bethesda, MD. 20034.
- Conde, Vincent, McGill University (Redpath Museum), Montreal, Canada.
- Cooper, Robert W., 5012 Pfeiffer Rd., Peoria, IL. 61607 (Florida marine; *Murex*, *Pecten*, *Spondylus*, SCUBA).
- Corgan, Dr. James X., Dept. of Geography and Geology, Austin Peay State Univ., Clarksville, TN. 37040 (Microscopic gastropods).
- Countryman, William D., R.D. 1, Northfield, VT. 05663 (Mollusca of Vermont).
- Courtney, Charles M., 390 Ortega Lane, Marco Island, FL. 33937 (Aquatic ecologist/malacologist).
- Craig, Michael M., Div. of Biol. Sciences, the Univ. of Mich., Ann Arbor, MI. 48104.
- Craig, Katherine B., 24 Savoy St., Colonia, NJ. 07067 (Mollusks of N.E. Coast of U.S.).
- Craine, Mrs. Ruth A., Penick Memorial Home "F", East Rhode Island Ext., Southern Pines, NC. 28387.
- Cramer, Frances L., 766 Obispo Ave., Long Beach, CA. 90804 (Ecology; conservation).
- Croft, Mrs. Thomas L., 9393 Ladue Rd., St. Louis, MO. 63124 (Marine; fossils).
- Cull, Mrs. Robert R., 7927 Chippewa Rd., Brecksville, OH. 44141.
- Cummings, Raymond W., 37 Lynacres Blvd., Fayetteville, NY. 13066 (West Indies shells, esp. Windward and Grenadine Is.).
- Cutler, Mr. and Mrs. Henry H., 105 Abbott Rd., Wellesley Hills, MA. 02181.
- Cvancara, Dr. Alan Milton, Dept. Geology, Univ. of N. Dakota, Grand Forks, ND. 58201 (Pleistocene and Holocene continental mollusks, early Tertiary continental and marine).
- Danforth, Louise L., 2529 Terry Lane, Sarasota, FL. 33581.
- Daniels, Mrs. Kathleen K., Box 265 A, Rt. 1, Apollo, PA. 15613 (*Haliotis*, *Murex*, *Spondylus*, *Pectinidae*, *Conus*, *Cypraea*, in order listed).
- Daniels, Ronnie H., 101 Brock Ave., Blytheville, AR. 72315 (Marine: *Volutes*, *Murex*, *Cowries*).
- Darwin, Sue, Suite D-a-A, R.D. 3, Box 250, Hockessin, DE. 19707.
- Davenport, Mrs. Lillian B., 802 Cape Ave., Cape May Point, NJ. 08212 (Anything pertaining to the sea).
- Davis, Dr. Derek S., Nova Scotia Museum, 1747 Summer St., Halifax, Nova Scotia, Canada B3H 3A6 (Gastropod biology and taxonomy).
- Davis, Dr. George M. and Davis, Dr. Elaine Hoagland, Dept. of Mollusks, Academy of Natural Science, 19th and the Parkway, Philadelphia, PA. 19103, and (Mrs.) Ass't. Prof. of Biology, Lehigh Univ., Bethlehem, PA. 18015.
- Davis, Dr. John D., 26 Norfolk Ave., Northampton, MA. 01060 (Ecology of marine bivalves).
- Deatrick, Paul A., 218 S.W. 32 Ave., Miami, FL. 33135 (*Strombus*, *Busycyon*).
- de Graaff, Gerrit, 10915 S.W. 55 St., Miami, FL. 33165.
- DeLuca, Mrs. John A., and Ms. Gladys DeLuca, 61 Deborah Rd., Hanover, MA. 02339.
- Dennis, Ms. Sally, TVA, Forestry, Fisheries, and Wildlife Develop., Norris, TN. 37828 (Freshwater mussels).
- DeOliveira, Dr. Maury Pinto, Dept. Biologia-Malacologia, Universidade Federal De Juiz De Fora, Cidade Universitaria, 36100 Juiz de Fora, Minas Gerais, Brazil.
- Demond, Miss Joan, 4140 Grandview Blvd. #1, Los Angeles, CA. 90066.
- Dexter, Miss Norma, 135 E. Main St. #3, Clinton, CT. 06413 (*Cypraea*).
- Dexter, Dr. and Mrs. Ralph W., Dept. Biological Science, Kent State Univ., Kent, OH. 44242.
- Dietrich, Mr. and Mrs. Louis E., 308 Veri Dr., Pittsburgh, PA. 15220.
- Dillon, Robert T., Jr., 1140 Club Rd., Waynesboro, VA. 22980.
- Dixon, Mrs. Ruth S., 711 Parker St., Durham, NC. 27701 (Marine).
- Dobos, John D., 1300 Porter, Apt. 45, Dearborn, MI. 48124.
- Dolin, Eric, 107 Briar Brae Rd., Stamford, CN. 06903 (*Conus*, *Cypraeidae*, *Strombus*, *Voluta*).
- Draper, Bertram, C., 8511 Bleriot, Los Angeles, CA. 90045 (Eastern Pacific minute mollusks and all Western U.S. marine).
- Druger, Dr. George, Memorial Hospital Medical Bldg., 500 Memorial Ave., Cumberland, MD. 21502 (SCUBA).
- DuBar, Dr. and Mrs. Jules R., Lakeview Hgts., Morehead, KY. 40351 (Cenozoic and recent mollusks-ecology and paleoecology).
- Dundee, Dr. Dolores S., Dept. of Biology, Univ. of New Orleans-Lakefront, New Orleans, LA. 70122 (Land mollusks, freshwater mussels).
- Dvorak, Stanley J., 3856 W. 26th St., Chicago, IL. 60623 (Muricidae).
- Dyer, Mr. and Mrs. John S. Jr., Box 238, Brookside, NJ. 07926 (Gastropods).
- Eakle, Christine E., Rackey, William A., 2308 Breton Dr., District Heights, MD. 20028 (Worldwide collecting).
- Eddison, Grace G., M.D., "Wildwood," Rt. 4, Carlisle, KY. 40311.
- Edwards, Lt. Col. Corinne E., USAF (Ret.), P.O.Box 691, Coconut Grove, FL. 33133 (Chitons; self-collected).
- Edwards, D. Craig, Dept. of Zoology, Morrill Science Center, Univ. of Massachusetts, Amherst, MA. 01002

- (Population ecology and behavior of marine benthic molluscs).
- Emerson, Dr. William K., American Museum of Natural History, Central Park West at 79th St., New York, NY. 10024.
- English, Rita C. and English, James F., 10300 Terrace Court, Parma, OH. 44130 (Fossils; Florida and Caribbean; ecology of mangrove areas).
- Erickson, Carl W., 4 Windsor Ave., Auburn, MA. 01501.
- Eubanks, Dr. Elizabeth R., 2162 E. Minton Dr., Tempe, AZ. 85282 (Florida marine).
- Evans, Miss Susan E., 244 Congress Ave., Lansdowne, PA. 19050 (*Conus*, *Cypraea*, *Murex*).
- Eversole, Dr. Arnold G., Dept. of Entomology and Economic Zoology, Clemson Univ., Clemson, SC. 29631 (Interpopulation variation and bioenergetics of molluscan populations).
- Fackert, Miss Dorothy M., 2 Wilson Rd., Apt. 16B, Sussex, NJ. 07461.
- Fair, Ruth H., Apt. 107, 14800 Memorial Dr., Houston, TX. 77079.
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- Flansburg, Dr. Ronald R., 2910 Pomona Court, Brookfield WI. 53005.
- Foehrenbach, Jack, 91 Elm St., Islip Manor, NY. 11751 (Marine ecology).
- Fontanier, Charles E., 127 Hallmark House, 316 Fry St., Denton, TX. 76201 (*Cypraea*idae, *Unionidae*; *Scuba*).
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- Fowler, Dr. and Mrs. Lake, 4508 Woodrow, Galveston, TX. 77550.
- Fox, Mr. and Mrs. Arnold, 112 Rennard Place, Philadelphia, PA. 19116 (*Pecten*, *Spondylus*, *Murex*).
- Franz, Dr. David R., Biology Dept., Brooklyn College, Brooklyn, NY. 11210 (Ecology and physiology, marine mollusks, esp. Nudibranchs).
- Franzen, Dr. Dorothea, Illinois Wesleyan Univ., Bloomington, IL. 61701.
- Fraser, Stanley, Box 966, Smiths Falls, Ont., Canada K7A 5A5.
- Frye, Mark W., 3521 Liv-Moor Dr., Columbus, OH. 43227 (Naiads, Micropaleontology with specialty in Ordovician micro-mollusks).
- Fuller, Samuel L.H. and Mrs. Mary L.B. Fuller, Academy of Natural Sciences, 19th and the Parkway, Philadelphia PA. 19103 (World Naiads, Unionacea and Mutelacea).
- Fullington, Richard W. and Kate E., 215 Bonnie Brae, Denton, TX. 76201.
- Gale, Dr. William F., Ichthyological Assoc. Inc., R.D. #1, Berwick, PA. 18603 (Sphaeriids).
- Galindo, Lic. Ernesto Santos, Lopez #1, 6o, Piso, Mexico, D.F.I., Mexico.
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- Gilbert, Dr. William H., and Dr. Mary Ann Gilbert, Environmental Studies, Ottawa Univ., Ottawa, KANS. 66067.
- Gilmour, Dr. Thomas H.J., Dept. Biology, Univ. of Saskatchewan, Saskatoon, Sask., Canada S7N 0W0 (Anisomyarian bivalves).
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- Goethel, Lt. Col. (Ret.) and Mrs. Louis N., 9402 Nona Kay Dr., San Antonio, TX. 78217 (*Cypraea*-buy and trade).
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- Greenberg, Mrs. Ruth, 22762 Pacific Coast Hwy., Malibu, CA. 90265 (Tidepool Gallery).
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- Gudnason, Mrs. Harold, 105 Danefield Place, Moraga, CA. 94556.

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- Gunter, Dr. Gordon, Gulf Coast Research Lab., Ocean Springs, MS. 39564 (Ostreidae).
- Gussman, David S., Pennsylvania State Univ., Dept. of Biology, 208 Life Science I, University Park, PA. 16802 (Aquatic ecology, feeding dynamics of aquatic organisms).
- Gustave, Al, 3829 North Third St., Phoenix, AZ. 85012 (*Murex*, *Astraea*, *Latialis*).
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- Harry, Dr. Harold W., 4612 Evergreen St., Bellaire, TX. 77401.
- Hartman, Joseph H., Dept. Geology/Geophysics, Univ. of Minn., 108 Pillsbury Hall, Minneapolis, MN. 55455 (Cretaceous-Eocene F.W. moll. of W. US; viviparidae).
- Haven, Dr. Dexter S., 336 Lafayette Rd., Yorktown, VA. 23690 (*Mercenaria mercenaria*, *Mya arenaria*, *Crassostrea virginica*).
- Havens, Miss Susan E., 21 Varnum Ave., Pawtucket, RI. 02860 (Student).
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- Heck, Lt. Col. Ralph L., P.O. Box 16712, Temple Terrace, FL. 33617 (Gastropods, esp. *Conus*, *Cypraea*).
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- Hickman, Mrs. Harriette L., 20 Wilkie Blvd., Mamora, NJ. 08223 (Worldwide *Epitonium*).
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- Hohman, Betty Jean, 10 Ferris, Apt. 101, Highland Park, MI. 48203 (cones, Volutes, Muricea).
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- Hoyer, Kerry Bryce, 1210 S. Downing, Seaside, OR. 97138 (Olives, Cones, Cowries, *Murex*).
- Hubbard, Mrs. Marian S., 3957 Marlow Court, Seaford, NY. 11783 (Littorinidae; all juvenile mollusks).
- Hubricht, Leslie, 4026 35th St., Meridian, MS. 39301 (U.S. land and freshwater).
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- Hunter, Dr. R.D., 1630 W. Buell Rd., Lake Orion, MI. 48035 (Physiological ecology of freshwater pulmonates).
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- Ing, Mrs. May C. and Michael B. Ing, Bella Vista Hospital Box 1750, Mayaguez, Puerto Rico 00708 (Small and minute shells of W.I.).
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- Jenneweine, Mr. and Mrs. Paul R., Box 394, Wrightsville Beach, NC. 28480 (Raising mollusks in aquaria; writing and illustrating articles on shell collecting).
- Jensen, Russell H., Box 3937, Delaware Museum of Natural History, Greenville, DE. 19807 (Mollusks of Bermuda).
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- Kovach, Jack, Dept. of Geology, Muskingum College, New Concord, OH. 43762 (Ecology, shell composition, paleontology of non-marine).
- Kraemer, Dr. Louise Russert, Dept. of Zoology, Univ. of Arkansas, Fayetteville, AR. 72701 (Freshwater lamelli-branchs).
- Kraeuter, Dr. John N., Virginia Institute of Marine Science, Wachapreague, VA. 23480 (Ecology, distribution and systematics of Scaphopoda; benthic infaunal of U.S. East Coast).
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- Krieger, Kenneth A., P.O. Box 22721 Emory Univ., Atlanta, GA. 30322 (Ecology and systematics of Hydobidae and Pleuroceridae).
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- Mathiak, Mr. and Mrs. Harold A., 209 S. Finch St., Horicon, WI. 53032 (History of Wisconsin mussels; species distribution).
- Matera, Albert and Mrs. Emily, 4501 Traymore St., Bethesda, MD. 20014 (*Murex*).
- Mauseth, E.L., Alden, MN. 56009.
- Mazurkiewicz, Michael, Associate Prof. of Biology, Depart. Biological Sciences, Univ. of Maine at Portland-Gorham, 96 Falmouth St., Portland, ME. 04103 (Larval development and ecology of estuarine mollusks).
- McCaleb, John E., Highland Garden Apts., Bldg. E, Apt. B-5, 850 Schuyll Kill Rd., Pottstown, PA. 19464 (Freshwater mollusks of N.A., esp. *Pleuroceridae*).
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- Metcalf, Dr. Artie L., Dept. of Biology, Univ. of Texas at El Paso, El Paso, TX. 79968 (Terrestrial Gastropoda of S.W. U.S.).
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- Miller, Richard L., Dept. of Biology, Temple Univ., Philadelphia, PA. 19122.
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- Murray, Mr. and Mrs. Talbot E. Jr., Grad. Sch. of Oceanography, Univ. of R.I., Narragansett, RI. 02882.
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- Naide, Dr. Meyer, 2034 Spruce St., Philadelphia, PA. 19103.
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- Nicolais, Mr. and Mrs. Domenick, Bella Vista Is., Box 147, Fairhaven, MA. 02719 (*Pecten*; exchange).
- Nielsen, Richard L., Box 278, Fletcher Academy, Fletcher, NC. 28732 (Non-marine aquatic mollusks).
- Noseworthy, Ronald G., P.O. Box 104, Main St., Grand Bank, Newfoundland, Canada AOE 1W0 (North Am. circumboreal mollusks; also Clausiliidae and Turridae).
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- Odé, Dr. Helmer, 4811 Braeburn Dr., Bellaire, TX. 77401 (Gulf of Mexico marines).
- Oesch, D. Ronald, 9 Hill Dr., Glendale, MO. 63122 (Missouri mussel zoogeography).
- Oetzell, Miss Edith M., 518 S. Ardmore Ave., Villa Park, IL. 60181 (*Conus*).
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- Olinger, Michele, 2307 Sastre, South El Monte, CA. 91733 (Intertidal Gastropoda of Southern California).
- Olsen, Philip L., 10708 Blossom Lane, Silver Spring, MD. 20903 (Cape Hatteras to Cape Cod mollusks).
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- Paine, Walter C., Assoc. Curator, Malacology, Montshire Mus. of Science, 45 Lyme Rd., Hanover, NH. 03755.
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- Parker, John Dyas, Box 318, Chestnut Ave., West Grove, PA. 19390 (Tertiary fossils and historical conchology).
- Parodiz, Dr. and Mrs. Juan Jose, Sect. of Invertebrates, Carnegie Museum, 4400 Forbes Ave., Pittsburgh, PA. 15213 (Neotropical mollusks and freshwater Gastropoda of USA).
- Pate, John B., P.O. Box 1025, Arnsda, CO. 80001 (Amateur shell and fossil collector; Panamanian shells).
- Parnallee, Dr. Paul W., Prof. of Zooarchaeology, Dept. of Anthropology, Univ. of Tenn., Knoxville, TN. 37916 (Freshwater mollusks from archaeological sites).
- Papp, Mrs. Zoltan, Schnecksville, PA. 18178.
- Paul, A.J., Seward Marine Station, Institute of Marine Science, Box 617, Seward, AK. 99664 (Biology of commercially harvested Gastropods of Bering Sea, esp. *Neptunea pribloffenensis*).
- Pearson, Kermit, Gloria, and Eric, Box 1002, APO, San Francisco, CA. 96555 (Kwajalein Atoll, Kwajalein Island, Missile Range, interested in exchange).

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- Phillips, Betty and Ted, 4580 Nueces Dr., Santa Barbara, CA. 93110.
- Pierce, Dr. Harold G., Dept. of Civil Engineering and Geology, Virginia Military Institute, Lexington, VA. 24450 (Local fauna interest).
- Piplani, Shirley A., 26 Jameson Place, West Caldwell, NJ. 07006 (Chitons).
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- Porter, Mrs. Miriam E., 2013 S. Vernon Pl., Melbourne, FL. 32901.
- Post, Mrs. Alfred P. Jr., P.O. Box 65, Darlington, MD. 21034.
- Powers, Joe, Bonded Oil Co., 2525 N. Limestone St., Springfield, Ohio 45501 (Marine Shells Worldwide).
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- Queen, Lorna B. (Mrs. C.B.), P.O. Box 326, Maysville, NC. 28555 (Mollusks of the Southeast Atlantic).
- Racela, Dr. Antonio Jr. and Dr. Luz Racela, 126 W. 116th St., Kansas City, MO. 64114 (Philippine land and marine shells).
- Radwin, Dr. George E., 4341 Rodrigo Dr., San Diego, CA. 92115 (Gastropod taxonomy).
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- Raup, Timothy A., 910 Farrell Ave., Kalamazoo, MI. 49007 (*Conus*).
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- Rawls, Dr. Hugh C., Eastern Illinois Univ., Dept. of Zoology, Charleston, IL. 61920 (Ecology, taxonomy, distribution of land snails).
- Raymond, Torrance C., 99 Ridgeview Rd., Poughkeepsie, NY. 12603.
- Reader, Mr. and Mrs. William R., 4772 49th Ave. North, St. Petersburg, FL. 33714 (Live mollusks).
- Reeder, Richard L., Faculty of Nat. Sci., Univ. of Tulsa, Tulsa, OK. 74104 (Land pulmonates).
- Rehder, Dr. and Mrs. Harald A., 5620 Ogden Rd., Washington, DC. 20016.
- Rhode, Homer J., 977 Botany Lane, Rockledge, FL. 32955 (Marine collecting).
- Rice, Thomas C., Of Sea and Shore Publications, P.O. Box 33, Port Gamble, WA. 98364 (Dealer).
- Richards, Charles S., Lab. of Parasitic Diseases, National Institute of Health, Bethesda, MD. 20014 (Freshwater mollusks, host-parasite relations, mollusk pathology and genetics).
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- Riley, Bobby J., 4312 Lahanna Dr., Louisville, KY. 40216 (*Terebridae*, *Olividae* and *Fasciolaridae*).
- Ritchie, Mrs. Robert M., 17 Country Club Pl., Bloomington, IL. 61701.
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- Roper, Dr. Clyde F.E. and Ingrid, Div. of Mollusks, U.S. National Museum, Washington, DC. 20560 (Systematics and ecology of Cephalopoda).
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- Roworth, Edwin C., 1361 Windsor Rd., Cardiff-by-the-Sea, CA. 92007 (World shells and sea life).
- Ruehl, Theodore, C., Rt. 202, 112 Haverstraw Rd., Suffern, NY. 10901 (*Murex*, *Voluta*, *Conus*).
- Russell, Charles E., 10602 Jordan Rd., Carmel, IN. 46032 (land; freshwater shells).
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- Rutter, Kurt L., P.O. Box 107, Stanton, NJ. 08885 (Shells of the littoral area).
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- Sartor, James C., 5606 Duxbury, Houston, TX. 77035 (Microscopic marine mollusks—exchange or purchase).
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- Schell, Frederic B. Jr., 1200 Peppertree Lane, Apt. 102, Sarasota, FL. 33581 (winter); The Brooklands, Colebrook, CT. 06021 (May 15–Oct. 15).
- Schilling, Mr. and Mrs. Albert E., 419 Linden Ave., Glenside, PA. 19038 (Mr. -*Cypraea*; Mrs. -*Murex*; both, *Conus*).
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- Sparks, Mrs. Mary K., Possum Trot Farm, Unionville, IN. 47468 (*Cypraea*, *Murex*, Ecology of marine habitats, exchange).
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- Stainken, Dennis, 51 Coughlan Ave., Staten Island, NY. 10310 (Anatomy and physiology of bivalves; effects of marine pollutants).
- Stansbery, Dr. David H., Museum of Zoology, Ohio State Univ., 1813 North High St., Columbus, OH. 43210 (Naiads).
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- Steger, Mrs. Dan, 2711 68th St., Tampa, FL. 33619 (Marine fauna of Gulf of Mexico).
- Stein, Dr. Carol B., Museum of Zoology, Ohio State Univ. 1813 North High St., Columbus, OH. 43210 (Naiads, Gastropoda).
- Stenzel, Dr. H.B., Dept. of Geology, Louisiana State Univ., Baton Rouge, LA. 70803.
- Stern, Dr. Edward M., Dept. of Zoology and Physiology, Louisiana State Univ., Baton Rouge, LA. 70803 (Systematics and ecology of terrestrial gastropods and Unionidae).
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- Strenth, Dr. Ned E., The Marine Biomedical Institute, 200 Univ. Blvd., Galveston, TX. 77550 (General ecology, systematics, and larval development of opisthobranch molluscs of genus *Aplysia*).
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- Talbot, Robert 2640 Killarney Rd., Victoria, British Columbia, Canada V8P 3G8 (Conidae, Cypraeaidae of Pacific; intertidal life of Pacific Northwest).
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- Vokes, Dr. Harold and Dr. Emily, Dept. of Geology, Tulane Univ., New Orleans, LA. 70118 (Mesozoic and Tertiary mollusks; fossil and recent Muricidae).
- Wagner, Mr. and Mrs. Robert J.L., R.D. 1, Box 21, Marathon, FL. 33050 (Purchase shells).
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- Walter, Dr. Waldemar, Dept. of Biological Sci., Western Illinois Univ., Macomb, IL. 61455.
- Ward, Wilson B., P.O. Box 26341, Houston, TX. 77207 (*Cypraea*, *Conus*, representative worldwide).
- Warmke, Germaine L., 1711 S.W. 43rd Ave., Gainesville, FL. 32508 (Shells of Puerto Rico).
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- Wright, Fran (Mrs. R.), 10360 S.W. 121 St., Miami, FL 33176.
- Wu, Mr. and Mrs. Shi-Kuei, c/o Univ. of Colorado Museum, Boulder, CO 80309 (Functional morphology of mollusks; Muricid gastropods; land and freshwater mollusks of Rocky Mountain area).
- Wulff, Mrs. Elia May, R.D. 2, Bella Vista Dr., Willimantic, CT 06226 (Marine gastropods).
- Wurtz, Dr. Charles B. 3220 Penn St., Philadelphia, PA 19129 (Terrestrial Pulmonata).
- Yergin, Margaret (Maggi), 2706 Cameron Blvd., Isle of Palms, SC 29451 (Marine mollusks).
- Yochelson, Dr. Ellis, U.S. Geological Survey, E. 317, U.S. National Museum, Washington, DC 20560.
- Yokley, Dr. Paul Jr., Box 5153, Univ. North Alabama, Florence, AL 35630.
- Young, Mrs. Ann Frame, P.O. Box 846, Marathon, FL 33050 (Scuba, Cassidae).
- Young, H.D. and Wilma G. Young, P.O. Box 1931, Seattle, WA 98111 (Exchange Pacific Northwest gastropods; also purchase).
- Young, Miss M.E., 6314 Waterway Dr., Falls Church, VA 22044.
- Zager, Mrs. Jane, Hollybrook 54-303, 8930 S. Hollybrook Blvd., Pembroke Pines, FL 33025 (American shells).
- Zoeller, Mr. and Mrs. E. Nelson, 360 Phillips Hill Rd., New City, NY 10956 (Worldwide; specializing in Polymita and Helicostyla).

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- Altena, Dr. C.O. van Regteren, Duindoornlaan 26, Bentveld, Holland.
- Ant, Professor Dr. Herbert, Wielandstr. 17, D-47 Hamm, Germany.
- Baba, Dr. Kikutaro, Shigagaoka 35, Minami-11-jo, Sango-cho, Ikoma-gun, Nara-ken, Japan 636 (Opisthobranchia—taxonomy, morphology).
- Boettger, Dr. Caesar, Zoologisch Inst., Gueldenstr. 408 3300 Braunschweig, West Germany.
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- Pajer, Miss Zdenka, Tomcsicova 8, 64000 Kranj (Slovenija), Yugoslavia.
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- Rong, Hwang Shin, P.O. Box 58530 Taipei, Taiwan, (Cypraeidae, Conidae).
- Schribner, Alvan and Dolores (Mr. and Mrs.), c/o Philco Ford, Jask, Iran (Persian Gulf area of Iran).
- Trinidad, Dr. Victor Jose V., #10 Orchid St., Capitol Site, Cebu City, Philippines 6401 (Cowries, cones, olive and Tibia shells).
- Upatham, Dr. Edward Suchart, Biology Dept., Faculty of Science, Mahidol Univ., Bangkok, Thailand.

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In Memoriam

J. Chester Bradley

Ralph E. Broyles

Allyn G. Smith

Sue Darwin

Mrs. Jack H. Merritt

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NOTICES

NEXT AMU MEETING: Naples, Florida — July 11-15, 1977. See Spring Newsletter for details.

HOW TO STUDY AND COLLECT SHELLS, latest edition of the popular symposium published by the American Malacological Union, may be purchased for \$2.50 each from Paul Jennewein, Corresponding Secretary, Box 394, Wrightsville Beach, NC. 28480. Regular bookseller's discounts are available for purchase of copies of 10 to 50 copies.

The **INDEX TO THE BULLETINS OF THE AMERICAN MALACOLOGICAL UNION**, through 1974, prepared by Mrs. Margaret Teskey, is available for \$6.50 postpaid. U.S. funds should be sent to Myra L. Taylor, Treasurer, 7602 McCullough Ave., San Antonio, TX. 78216.

The tenth annual meeting of the Western Society of Malacologists will be held June 15 to June 18, 1977, at Kellogg West, Center For Continuing Education, California State Polytechnic University, Pomona, California. The program will include contributed papers, symposia, exhibits, and study workshops on molluscan subjects. Inquiries about the meeting should be directed to Mrs. Jo Ramsaran, Secretary, 807 North Road, San Bernardino, CA. 92404.

The Sixth European Malacological Congress of the UNITAS MALACOLOGICA EUROPAEA will be held in the week 15-20 August, 1977, in the Free University, Amsterdam. Apart from the usual items on the programme such as a meeting of the European Invertebrate Survey, field trips, and the General Assembly of the U.M.E., there will be twenty main lectures by specialists in the various fields.

All malacologists, i.e., everybody working with molluscs, whether in a professional capacity or not, are invited to attend the Amsterdam congress. For further information write to Sixth European Malacological Congress, c/o Congressbureau van de Vrije Universiteit, De Boelelaan 1105, Amsterdam, Holland.

The fees will be as follows: Hfl. 100.—for full congress members (approximately US\$ 40), Hfl. 20.—for associate members (e.g., accompanying ladies), and Hfl. 50.—for student members.

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Exhibit:

A.M. Frias-Martins:
"Photographs of Mollusks
from the Azores."

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